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NATIONAL DAM SAFETY PROGRAM. ORANGE RESERVOIR DAM (NJ 00361), R--ETC(U)
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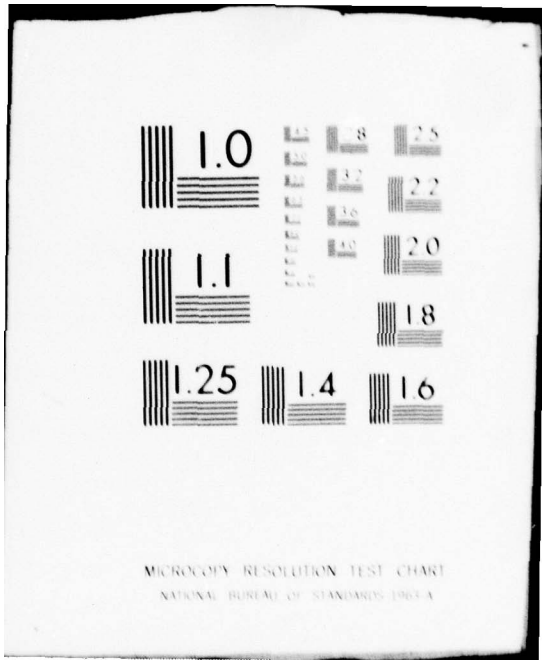
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RAHWAY RIVER WEST BRANCH
ESSEX COUNTY,
NEW JERSEY

ORANGE RESERVOIR DAM
NJ 00361

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DEPARTMENT OF THE ARMY
Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

February, 1979

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

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4. TITLE (and Subtitle): Phase I Inspection Report
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Orange Reservoir Dam
Essex County, N.J.

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7. AUTHOR(s): (10) Robert J. Jenny P.E.

8. CONTRACT OR GRANT NUMBER(s): (15) DACW61-78-C-0124

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
Jenny-Leedshill Engineering
318 South Orange Ave.
South Orange, N.J. 07079

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:

11. CONTROLLING OFFICE NAME AND ADDRESS: (11)
U.S. Army Engineer District, Philadelphia
Custom House, 2d & Chestnut Streets
Philadelphia, Pennsylvania 19106

12. REPORT DATE: Feb[illegible], 1979

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Approved for public release; distribution unlimited.

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(6) National Dam Safety Program. Orange Reservoir Dam (NJ ØØ361), Rahway River Basin, Rahway River West Branch, Essex County, New Jersey. Phase I Inspection Report.

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dams
Embankments
Spillway
Visual Inspection
National Dam Inspection Act rpport
Orange Reservoir Dam, N.J.
Structural Analysis

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-D

7 MAY 1979

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Orange Reservoir Dam in Essex County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Orange Reservoir Dam, a high hazard potential structure, is judged to be in good overall condition. However, the spillway is considered seriously inadequate since 19 percent of the Probable Maximum Flood (PMF) would overtop the dam. The seriously inadequate spillway is assessed as an UNSAFE, non-emergency condition, until more detailed studies prove otherwise or corrective measures are completed. The classification of UNSAFE applied to a dam because of a seriously inadequate spillway is not meant to indicate the same degree of emergency as would be associated with an UNSAFE classification applied for a structural deficiency. It does mean, however, that based on an initial screening, and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard of loss of life downstream from the dam. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980. In the interim, a detailed emergency operation plan and warning system, should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

b. Within six months from the date of approval of this report, engineering studies and analyses should be performed to determine the dam's embankment and foundation condition and structural stability. This should include test borings to determine material properties relative to stability and seepage and installation of piezometers to facilitate seepage studies. Any remedial measures found necessary should be initiated within calendar year 1980. The dam should be surveyed to confirm its as built geometry.

c. The following remedial actions should be completed within thirty days from the date of approval of this report:

(1) All trees on the crest of the dam should be cut flush with the surface and removed.

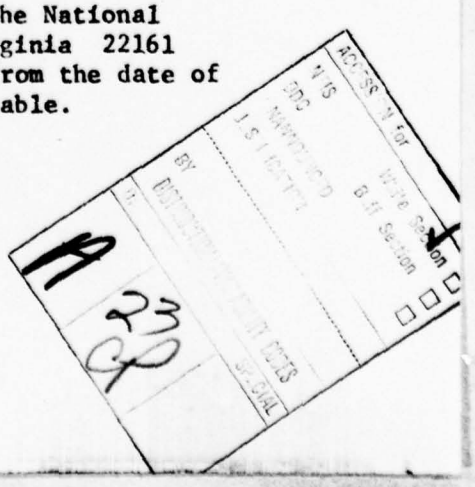
(2) All brush and small trees should be removed from the downstream face of the dam.

(3) Stones dislodged from the upstream end of the right spillway wing wall should be replaced.

d. Within one year from the date of approval of this report a program of annual inspection of the dam together with a program to record all operating and maintenance activities, should be initiated. The peeling and spalling of the spillway apron should be carefully observed, and remedial work performed should the deterioration continue. The area of potential slope instability located on the left bank of the reservoir approximately 300 ft. upstream at the spillway also warrants close inspection.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Joseph Minish of the Eleventh District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.



NAPEN-D
Honorable Brendan T. Byrne

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Copies furnished:
Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N. J. Dept. of Environmental Protection
P. O. Box CN029
Trenton, NJ 08625

John O'Dowd, Acting Chief
Bureau of Flood Plain Management
Division of Water Resources
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Trenton, NJ 08625

ORANGE RESERVOIR DAM (NJ00361)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 2 and 16 December 1978 by Jenay-Leedshill Engineers under contract to the State of New Jersey. The state, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Orange Reservoir Dam, a high hazard potential structure, is judged to be in good overall condition. However, the spillway is considered seriously inadequate since 19 percent of the Probable Maximum Flood (PMF) would overtop the dam. The seriously inadequate spillway is assessed as an UNSAFE, non-emergency condition, until more detailed studies prove otherwise or corrective measures are completed. The classification of UNSAFE applied to a dam because of a seriously inadequate spillway is not meant to indicate the same degree of emergency as would be associated with an UNSAFE classification applied for a structural deficiency. It does mean, however, that based on an initial screening, and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard of loss of life downstream from the dam. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980. In the interim, a detailed emergency operation plan and warning system, should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

b. Within six months from the date of approval of this report, engineering studies and analyses should be performed to determine the dam's embankment and foundation condition and structural stability. This should include test borings to determine material properties relative to stability and seepage and installation of piezometers to facilitate seepage studies. Any remedial measures found necessary should be initiated within calendar year 1980. The dam should be surveyed to confirm its as built geometry.

c. The following remedial actions should be completed within thirty days from the date of approval of this report:

(1) All trees on the crest of the dam should be cut flush with the surface and removed.

(2) All brush and small trees should be removed from the downstream face of the dam.

(3) Stones dislodged from the upstream end of the right spillway wing wall should be replaced.

d. Within one year from the date of approval of this report a program of annual inspection of the dam together with a program to record all operating and maintenance activities, should be initiated. The peeling and spalling of the spillway apron should be carefully observed, and remedial work performed should the deterioration continue. The area of potential slope instability located on the left bank of the reservoir approximately 300 ft. upstream at the spillway also warrants close inspection.

APPROVED: James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 7 May 1979

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN

21 FEB 1979

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

Dear Governor Byrne:

This is in reference to our ongoing National Program for Inspection of Non-Federal Dams within the State of New Jersey. Orange Reservoir Dam (Federal I.D. No. NJ00361), a high hazard potential structure has recently been inspected. The dam is owned by the City of Orange Public Works Department and is located on the West Branch of the Rahway River, approximately 1.5 miles northwest of the City of East Orange in Essex County.

Using Corps of Engineers screening criteria, it has been determined that the dam's spillway is seriously inadequate since approximately 19 percent of the Probable Maximum Flood would overtop the dam. The seriously inadequate spillway is assessed as an UNSAFE, non-emergency condition, until more detailed studies prove otherwise, or corrective measures are completed. The classification of UNSAFE applied to a dam because of a seriously inadequate spillway is not meant to indicate the same degree of emergency as would be associated with an UNSAFE classification applied for a structural deficiency. It does mean, however, that based on an initial screening and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard potential to loss of life downstream from the dam. As a result of this UNSAFE determination, it is recommended that the dam's owner take the following measures within 30 days of the date of this letter:

a. Engage the services of a qualified professional consultant to more accurately determine the spillway adequacy by using more detailed and sophisticated hydrologic and hydraulic analyses, and to recommend any remedial measures required to prevent overtopping of the dam.

b. In the interim, a detailed emergency operation plan and downstream warning system should be developed. Also, round-the-clock surveillance should be provided during periods of unusually heavy precipitation.

NAPEN-D
Honorable Brendan T. Byrne

A final report on this Phase I Inspection will be forwarded to you within two months.

Sincerely yours,

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

Cy Furn:
Dirk C. Hofman, Actg Deputy Director
Division of Water Resources
N.J. Dept of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

John O'Dowd, Acting Chief
Bureau of Flood Plain Management
Division of Water Resources
N.J. Dept of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

UNSAFE DAM
NATIONAL PROGRAM OF INSPECTION OF DAMS

a. NAME: Orange Reservoir

b. ID NO.: NJ 00361

c. LOCATION State: New Jersey County: Essex
River or Stream: West Branch of Rahway River
Nearest D/D City or Town: Millburn

d. HEIGHT: 34 Feet

e. MAXIMUM IMPOUNDMENT CAPACITY: 1015 ac. ft.

f. TYPE: Earth with cemented masonry core

g. OWNER: City of Orange, Public Works Dept.

h. DATE GOVERNOR NOTIFIED OF UNSAFE CONDITIONS: 21 Feb 79

i. CONDITION OF DAM RESULTING IN UNSAFE ASSESSMENT:
Preliminary report calculations indicate 19% of PMF would overtop the dam.

1. URGENCY CATEGORY: UNSAFE, Non-Emergency

m. EMERGENCY ACTIONS TAKEN:
Gov. notified of this condition by District Engineer's 21 Feb 79 letter.

j. DESCRIPTION OF DANGER INVOLVED:
Overtopping and failure of the dam significantly increases hazard potential to loss of life and property downstream of dam.

n. REMEDIAL ACTIONS TAKEN:
N.J.D.E.P. will notify dam's owner upon receipt of our letter.

k. RECOMMENDATIONS GIVEN TO GOVERNOR:
Within 30 days of date of District Engineer letter the owner do the following:
a. Engage the services of a qualified professional consultant to more accurately determine the spillway adequacy by using more detailed and sophisticated hydrologic and hydraulic analyses, and to recommend any remedial measures required to prevent overtopping of the dam.

b. In the interim, a detailed emergency operation plan and downstream warning system should be developed. Also, round-the-clock surveillance should be provided during periods of unusually heavy precipitation.

o. REMARKS: Final report, to be issued within six weeks, will have WHITE cover.

2/26/79
W. H. ZINK, Coordinator
Dam Inspection Program
U.S.A.E.D., Philadelphia

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Orange Reservoir Dam, Federal I.D. No. NJ00361, New Jersey I.D. No. 26-4
State Located:	New Jersey
County Located:	Essex
Stream:	West Branch Rahway River
Date of Inspection:	December 2 and 16, 1978 and January 4, 1979

Brief Assessment of General Condition of Dam

The present condition of the Orange Reservoir Dam is considered questionable in view of its lack of spillway capacity to pass the Probable Maximum Flood (PMF) without overtopping the dam. The spillway can pass a maximum of approximately 18 percent of the PMF and is judged to be seriously inadequate.

The dam appears to be in good condition structurally for its intended use based on inspection and review of available information.

The available engineering data are not sufficient to quantitatively analyze the structural stability of the dam.

Recommendations and the urgency of their implementation are as follows:

1. Studies to augment the spillway discharge capacity should be performed as soon as possible.
2. Soil borings and laboratory tests of the embankment and foundation materials should be made soon, piezometers installed and read, and seepage and stability analyses made by experienced soils engineers.
3. The dam should be surveyed to confirm its as-built geometry.
4. Studies to develop an effective warning system should be initiated very soon and the system should

be implemented in the near future.

5. A program of annual inspection of the dam should be initiated in the near future.
6. All trees on the crest of the dam should be cut flush with the surface and removed as soon as possible.
7. All brush and small trees should be removed from the downstream face of the dam as soon as possible.
8. Stones dislodged from the upstream end of the right spillway wing wall should be replaced as soon as possible.

Frank L. Panuzio

Frank L. Panuzio, P.E.
Project Engineer

Robert J. Jenny, P.E.
Project Director
New Jersey License No. 9878

ORANGE RESERVOIR DAM

View of dam from left abutment with spillway in foreground. (Dec. 2, 1978)

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

ORANGE RESERVOIR DAM
Federal I.D. No. NJ 00361
New Jersey I.D. No. 26-4

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

The National Dam Inspection Act, Public Law 92-367, 1972, provides for the National Inventory and Inspection Program by the U. S. Army Corps of Engineers. This report has been prepared in accordance with this authority, through contract between the State of New Jersey and Jenny-Leedshill Engineers. The State of New Jersey has also entered into an agreement with the U. S. Army Engineer District, Philadelphia, to have this work performed.

b. Purpose of Inspection

The purpose of this inspection was to evaluate the general structural integrity and hydraulic adequacy of the dam, and to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project

a. Description of Dam and Appurtenances

Orange Reservoir Dam is an earth dam with a cemented masonry core. The dam is 900 feet long and has a maximum height of 34.4 feet. The crest of the dam is at elevation 330.9 feet and has a width of 16 feet. The slope of the upstream face is 1 vertical on 3 horizontal and the downstream face slopes at 1 vertical on 2 horizontal.

The spillway structure, which was modified following original construction of the dam, is located on the left abutment. The upstream approach to the spillway is riprapped and the downstream chute consists of a concrete apron. Details of the spillway are shown in Plates 3, 4 and 5.

A miscellaneous fill has been placed on the downstream face of the dam adjacent to the spillway to widen the crest so that vehicles can turn around. A dumped rock dike, approximately 7 feet high was constructed along the west side of the channel downstream of the spillway to direct the overflow into the natural channel. The approximate locations of these structures have been superimposed on the original plan of the dam shown on Plate 3.

The outlet works consist of a submerged, concrete masonry intake structure with two outlet pipes in a tunnel passing through the base of the dam approximately 300 feet west of the spillway. The water supply outlet consists of a 20-inch diameter steel pipe which connects to a 16-inch diameter pipe at a gatehouse located at the downstream toe of the dam. The water supply outlet pipe has a by-pass valve which is used to enable cleaning of the outlet pipe. This valve is located in a concrete masonry vault approximately 50 feet downstream from the gatehouse. Water in the outlet pipe then passes into a concrete stilling chamber and through filter screens located in a fenced-in concrete structure.

A second 20-inch diameter pipe is an emergency outlet which empties into a small stilling basin located adjacent to the water supply filter screens.

b. Location

Orange Reservoir Dam is located on the West Branch of the Rahway River, approximately 1.5 miles northwest of the town of South Orange, in Essex County, New Jersey. The regional vicinity plan is presented on Plate 1.

c. Size Classification

The storage capacity of Orange Reservoir is 1015 acre-feet when the reservoir surface is at the dam crest; therefore, the size classification of the dam is Intermediate, even though the dam's size classification is small based on its 34.4 feet height.

d. Hazard Classification

Although no structures were visible immediately downstream from the dam, U. S. Geological Survey maps indicate that there are several structures and major road crossings downstream of the dam, including South Orange Avenue and the Township of Millburn, with a population of about 20,000, located approximately 2 and 4.2 miles downstream, respectively. Routing of the Probable Maximum Flood indicates that significant inundation and damage and possible loss of life could result in the township of Millburn. Therefore, the Orange Reservoir Dam merits a high hazard classification.

e. Ownership

The dam is owned by the City of Orange, Public Works Department, 29 North Day Street, Orange, New Jersey 07050.

f. Purpose of Dam

The reservoir is used for supplying water to the City of Orange.

g. Design and Construction History

The dam was reported to have been originally constructed in 1883. In 1958, the erosion and spalling of the spillway wing walls and concrete apron were repaired and the spillway crest was raised 1 foot. The riprap at the top of the dam was also replaced and grouted in 1958. Details of the 1958 repairs and modification are shown on Plates 2 and 5.

The miscellaneous fill at the east end of the dam has

reportedly been placed over the past 30 years. The dike along the spillway channel was constructed following flooding of the downstream toe of the dam as a result of Hurricane Doria in 1971.

The by-pass valve, stilling chamber, and screens for the water supply outlet are not shown on the plans and sections of the original dam. The date of construction of these facilities is not known.

h. Normal Operational Procedures

Water from the Orange Reservoir is released through a 20-inch outlet pipe and passes through a screening chamber located downstream of the toe of the dam. These screens are cleaned approximately every two weeks. The water then passes through a treatment plant and is distributed to the City of Orange. Releases through the outlet works are regulated by water supply demands.

An aerator was installed in 1977 and continuously pumps air into the reservoir through four outlets to oxidize manganese contained in the water.

1.3 Pertinent Data

a. Drainage Area - 4.62 square miles

b. Discharge at Damsite

- Maximum known flood at damsite - 1090 sec. ft. at Millburn on July 23, 1945.
- Ungated spillway capacity at maximum pool elevation - 1435 cfs.
- Total spillway capacity at maximum pool elevation - 1435 cfs.

c. Elevation* (ft. above MSL)

- Top Dam 330.90

*Report on Dam Application No. 517 notes that 'All elevations refer to Essex County Datum, which is 3.50 higher than stream survey datum.' Stream survey datum is assumed to be MSL.

· Maximum pool-design surcharge	330.64
· Spillway crest	327.50
· Streambed at centerline of dam	296.5 (Approx.)
· Maximum tailwater	305.2 (Approx. PMF without breaching)

d. Reservoir

· Length of maximum pool	5100 ft.

e. Storage (acre-feet)

· Design surcharge	245
· Top of dam	1015

f. Reservoir Surface (acres)

· Top dam	79 (Approx.)
· Spillway crest	65 (Approx.)

g. Dam

· Type	Earth with cemented masonry core wall
· Length (including spillway)	900 ft
· Height	34 ft. (Approx. Max.)
· Top Width	16 ft.
· Side Slopes - Upstream	1V:3H
- Downstream	1V:2H
· Zoning	'Gravel or other coarse material' downstream of core wall and 'Puddle' on upstream side
· Impervious Core	Cemented masonry core wall. Top of wall at elevation 328.5 ft.

h. Spillway

· Type:	Chute with modified broad crested weir control
· Length of weir:	71.5 ft.
· Crest elevation:	327.5 ft. (MSL)

- U/S Channel: Riprap
- D/S Channel: 62-ft. long reinforced concrete apron draining into a natural rock (basalt) channel

i. Regulating Outlets

- 1-20 in. diameter pipe for removal of sediments
- 1-20 in. diameter pipe tapering into a 16 in. pipe for water supply to City of Orange

SECTION 2: ENGINEERING DATA

2.1 Design

a. Geologic Conditions

Geologically, the Orange Reservoir Dam lies within the Piedmont Lowland physiographic province. A description of of the regional geology of this province is presented in Appendix C to this report.

Orange Reservoir and Dam is located in a north-south valley between the First and Second Watchung Mountains containing prominent basaltic lava flows interbedded within a matrix of red sandstones, shales and siltstones. The project is located near the easterly side of the valley near the First Watchung Mountain. This eastern valley wall is in fact the gentle dip slope of a basalt flow dipping to the northwest. The basalt can be seen on the left abutment where it it has been blasted out to form the spillway channel. The basalt, often called the "Newark" basalt, is a dark, dense, hard, homogeneous and massive rock with characteristic hexagonal, columnar jointing. Logs of borings (Plate 6) indicate that the left spillway abutment is founded on the basalt bedrock.

Trassic age shales and sandstones are known to be located between the two mountains but were not observed in the dam site area; however, the relative narrowness of the valley at this location is probably due to the erosion of these sedimentary rocks. These Triassic redbeds probably underlie the right abutment of the dam.

Overburden mapped in the area of the dam site includes ground moraine (glacial till), stratified glacial drift and recent alluvium. The ground moraine, seen on the left abutment, probably overlies bedrock throughout most of the

project area except in the pre-reservoir stream channel. Boring Number 3 (Plate 6) indicates that the bedrock is overlain by approximately 9 feet of overburden at the center of the spillway. The tills consist of an unsorted, heterogeneous material including clay, silt and sand with gravel, cobbles and boulders. Glacial till of this type can be expected to contain 30 to 60 percent material passing the 200 sieve and have a relatively low permeability.

Stratified glacial drift can be seen in a borrow pit approximately 400 feet downstream of the right abutment. The material consists predominantly of well-graded sand with varying amounts of silt, gravel and cobbles to 6-inch diameter. The material is typically red-brown in color with horizons of sandy cobbles which probably reflect periods of high velocity flows. These glacio-fluvial deposits probably overlie the glacial drift and, depending on the silt content, can be relatively permeable.

Recent alluvium consisting of silt, sand, gravel cobbles and boulders occupies the present stream channel downstream of the dam. Most of the material is derived from the till and stratified glacial drift.

Overall depth of overburden varies from probably less than 3 feet on the left abutment to more than 20 feet on the right abutment.

Since the area lies within Seismic Zone 1, only minor damage may be expected from distant earthquakes. No active faults are known to exist in the immediate vicinity nor surrounding area of the dam.

b. Design History

Existing and available data regarding the details of the design of the original dam are included in the "Report on Dam Application No. 517", filed with the State February 24, 1958 for the purpose of raising the originally constructed spillway one foot. Three sheets of drawings accompanying

this application show sections and plans of the embankment and spillway. These drawings also provide details of the proposed 1958 spillway modifications and repair including: the raising of the spillway; placement of a 4 in. reinforced concrete slab on the downstream spillway apron; and placement of riprap on the upper portion of the upstream face of the dam.

Specifications for the construction of the embankment are not available. However, as indicated by these available plans, (Plate 2) the embankment material downstream of the core wall was designed to be a 'gravel or other coarse material' and the material upstream of the core wall is 'puddle'. Riprap extends from the edge of the road at the crest of the dam and covers the entire upstream face of the dam. Approximately the upper 10 feet of masonry riprap is set in concrete.

Copies of these drawings are included as Plates 2, 4, and 5 of this report. Plans and sections of the dam and spillway are also presented on a drawing submitted with a letter from Clyde Potts Associates dated July 28, 1958. (See Plate 3) A drawing dated May 27, 1958 showing the location and logs of borings taken in the spillway and used to develop the cross-section of the spillway is shown on Plate 6.

Hydrology and hydraulic design computations for the original modified spillways are presented both in an Engineer's Report prepared by Clyde Potts Associates dated February 19, 1958 and the subsequent "Report on Dam Application No. 517" referred to above. Runoff from 150% Central Jersey Curve was used as the estimated design flood flow and 125% Central Jersey Curve was used to check backwater at the Northfield Avenue. After raising the spillway one foot the freeboard was determined to be 0,3 feet during the design flood flow of 1275 c.f.s.

No information is available regarding the original design of the outlet works. However, subsequent information that is available includes a set of post-construction survey notes showing the dimensions of the outlet works dated January 14, 1931; a photograph showing the intake structure when the reservoir was at elevation 307.0 and dated November 14, 1949 (Plate 7); and a diver's inspection report of the intake structure dated August 30, 1948. The diver's report indicates that the two upper inlets to the intake structure are open, but the bottom inlet has been plugged with bags of cement. Details of the structure are shown in Plates 2, 3, and 7.

2.2 Construction

No information regarding the construction of the original dam is available. Specifications for the raising of the spillway crest; repair of the spillway apron, stilling basin and walls; and placement of grouted riprap in the upper section of the upstream face of the dam are available, and were originally prepared by Clyde Potts Associates.

Repairs to the embankment consisted of placing and compacting impervious fill on the upstream embankment where settlement or erosion had occurred. Riprap consisting of stones weighing between 50 and 150 pounds were specified for placement on the top end of the upstream face of the embankment. The riprap was placed on a 6-inch layer of gravel and other porous material and the openings between the stones grouted after placement. (See Plate 2)

The original concrete apron on the downstream spillway channel was cleaned and the voids were cleaned of refuse and refilled with broken stone. The new reinforced concrete slab was poured in sections 15 feet by 30 feet which were separated by expansion joints consisting of premoulded joint filler.

2.3 Operations

The only information available regarding the operation of the dam and reservoir is that obtained verbally as described in Section 3.

2.4 Evaluation

a. Availability

Available engineering data for the original dam are limited to plans and sections and a qualitative description of the material in the embankment.

Detail drawings of the original and modified spillway (Plates 3, 4, and 5) are available together with logs of borings in the vicinity of the spillway (Plate 6).

b. Adequacy

The available design and construction data are inadequate to evaluate the structural stability of the dam.

The available data was generally adequate to perform the hydrologic and hydraulic evaluation; however, the reservoir stage-storage and the stage-discharge relationships for the outlet works, spillway and overtopping had to be estimated from U. S. G. S. maps and limited data available in State files.

c. Validity

Visual inspection of the dam indicates that the dam was constructed generally as shown on the available drawings.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

Visual inspections of Orange Reservoir Dam were made on December 2 and 16, 1978 and January 4, 1979. The water surface elevation at the time of the first inspection was just at the spillway crest with discharge from the reservoir passing through the spillway at about 100 gallons per minute.

The visual inspection did not reveal any critical signs of distress in the dam. There is evidence that minor erosion and possible minor uneven settlement of the downstream slope has taken place. Some peeling and spalling of the concrete surfaces of the spillway was evident.

Detailed inspection was made of the dam, appurtenent structures, reservoir area, and the downstream channel. Descriptions of the findings of these inspections are summarized in the paragraphs which follow. The checklist of visual inspection items is included in Appendix A. Geologic and foundation conditions observed at the time of inspection are noted in greater detail in Section 2.

b. Dam

The dam was inspected for signs of settlement, seepage, erosion, cracking, and any other evidence of undesirable behavior which might affect the stability of the structure.

An asphalt road extends along the entire length of the crest and trees 2.5 feet in diameter are located approximately 50 feet on center along the downstream edge of the crest. Riprap, consisting of 9-inch to 12-inch stones placed in concrete, lines the upstream face of the embankment below the crest of the dam. These features are shown in the Overview Photograph. The riprap appears to be in good condition and the crest of the dam is well aligned. No signs of cracking or distortion of the vertical and horizontal alignment were detected.

Most of the upstream face of the dam was submerged and could not be inspected below the spillway crest elevation.

At the time of the inspection there was no sign of seepage or dampness on the downstream face of the embankment or along the contacts of the embankment with the abutments and spillway on the downstream face. In addition, there was no evidence of leakage or seepage downstream of the dam.

The downstream face of the dam is covered with a heavy growth of grass and small brush and numerous trees (Photo 1). The slope of the downstream face of the dam is somewhat uneven and there is evidence of minor erosion and possibly minor uneven settlement.

A mixed fill consisting of soil and trash has been dumped along the downstream slope adjacent to the spillway (Photo 2). The approximate extent of this fill has been superimposed on the original plan of the dam shown in Plate 3. It was reported that the only purpose of the fill was to allow vehicles room to turn around at the end of the road over the dam crest.

c. Appurtenant Structures

Spillway

Inspection of the spillway indicates that the raising of the spillway crest and repair of the downstream apron were performed as shown on Plate 5. The concrete crest and apron appear to be in good condition with the exception of minor peeling and spalling of the concrete apron (See Photo 6). The most severe spalling of the surface of the concrete apron is at the downstream section adjacent to the embankment.

The spillway discharge channel immediately downstream consists of a rock (basalt) channel with some trees and debris (See Photo4).

Some stones have been dislodged from the upstream section of the right (west) masonry wing wall (Photo 3). Weep

holes are present in the spillway wing walls, but no flow was observed. Minor erosion of the left abutment has occurred adjacent to the concrete apron, downstream of the wing wall (Photo 5).

Some grass leaves, twigs and miscellaneous trash were present on the spillway (Photo 3). The approach to the spillway was submerged and therefore could not be inspected.

Outlet Works

The intake structure was submerged and could not be inspected.

The two outlet pipes were observed inside a 9-foot diameter brick and masonry tunnel, along with associated gate valves (Photo 8). These pipes are submerged in water about 2 feet deep. Water dripping slowly in the tunnel was heard during the inspection; however, the visible section of the tunnel appears to be in good condition. An air vent for the tunnel exits at the crest of the dam (Photo 7).

The concrete block vault housing a by-pass valve and pipe was opened for inspection. Approximately 1 foot of water was standing at the bottom of this vault but no leaks were observed that could account for the standing water. The outlet pipe or valve appeared in good condition with minor rusting and corrosion. The nearby screen chamber also appeared to be in good condition and no leakage was observed (Photo 9).

Reservoir Area

The slope on the east side of the reservoir is moderately steep at the spillway and for a distance of approximately 500 feet upstream. A 25-foot long section of the masonry wall which lines the rim of the reservoir in this area has collapsed. The potential for slope instability in this vicinity is relatively high, but it appears that any slipping would be limited in extent because of the apparently competent

bedrock underlying the shallow soil cover. The remainder of the shoreline of the reservoir is gently sloped and no indication of instability was noted. The entire perimeter of the reservoir is lined with masonry riprap and presents an exceptionally neat appearance.

The West Branch of the Rahway River enters the reservoir through a masonry-lined channel which passes under a bridge at Northfield Avenue (Photo 10). Two minor inlets enter from the eastern side of the reservoir.

Sedimentation did not appear to be a problem and the reservoir was free of any noticeable debris.

Downstream Channel

The downstream channel is heavily wooded and has a thick undergrowth. The area immediately downstream of the dam has been cleared in the vicinity of the outlet works (Photo 11).

The diversion dike downstream of the spillway appeared to be stable, although no effort has been made to shape the surface of the dike or to place riprap facing.

4.3 Maintenance of Operating Facilities

The outlet works are maintained by City of Orange workmen. Other than the emergency outlet works, most valves and appurtenances are operated on a fairly regular basis.

4.4 Description of Any Warning System in Effect

There are no alarms or similar warning devices. However, the City of Orange maintenance staff is present during the daytime and the Essex County Park Commission also patrols the area.

4.5 Evaluation of Operational Adequacy

The operational procedures are adequate for standard operation of the dam. However, increased surveillance of the dam in the evenings and particularly during heavy rains and possible floods should be considered. In addition, implementation of a warning system to alert downstream inhabitants in time of floods and possible overtopping of the dam should be planned and implemented.

SECTION 5: HYDRAULICS/HYDROLOGY

5.1 Evaluation of Features

a. Design

Orange Reservoir Dam has a maximum height of 34.4 feet and has a storage capacity of 1,015 acre-feet. In accordance with the Corps of Engineers, "Recommended Guidelines for Safety Inspection of Dams," the impoundment is classified as Intermediate in size. Because there are several structures and major road crossings downstream of the dam, there is high hazard to loss of life from large flows. The Corps guidelines indicate the Spillway Design Flood (SDF) for this size structure and hazard classification should be the Probable Maximum Flood (PMF).

The drainage area above Orange Reservoir Dam is reported by the Corps of Engineers to be 4.62 square miles. Data from State files indicate the drainage area is 4.55 square miles. The Corps requested that a basin size of 4.62 square miles be used in the hydrology analysis. The drainage basin is delineated on U. S. G. S. topographic maps and is presented on Plate D-1, Appendix D.

The drainage basin is rectangular in shape and roughly 3.8 miles long in the northeast-southwest direction and roughly 1.25 miles wide. Elevations range from about 600 feet mean sea level along the perimeter of the drainage basin to about 320 feet in the valley floor.

Land use patterns within the watershed consist of about 50 percent open space, mostly forests along the steeper slopes of the valley, and 50 percent developed areas. About 2 percent of the watershed area is the reservoir of the dam. There are several small reservoirs in addition to Orange in the basin. However, the combined drainage area of these reservoirs is insignificant.

The hydraulic and hydrologic features of the dam were

evaluated using criteria set forth in the Corps of Engineers, "Recommended Guidelines for Safety Inspection of Dams", and additional guidance and criteria provided by the Philadelphia District, Corps of Engineers. The Probable Maximum Precipitation (PMP) was calculated using Hydrometeorological Report No. 33 and the standard Hops Brook reduction factor of 0.80 for misalignment of the storm.

The Probable Maximum Flood (PMF) was calculated using the Corps' computer program HEC-1, Dam Break Version. In computing the PMF the Corps requested that the Clark unit hydrograph be used with Tc and R coefficients of 1.76 hours and 3.27 hours, respectively.

An initial infiltration loss of 1.0 inch and a final infiltration loss rate of 0.10 inches per hour were used in the HEC-1 program to give the rainfall excess. Using the excess rainfall and the unit hydrograph, the program computed the peak discharges of the PMF and one-half of the PMF. These discharges are 9295 cfs and 4648 cfs, respectively.

Several percentages of the PMF inflow hydrograph were routed through the reservoir using the Modified Puls Method by the HEC-1 program. The peak outflow discharges of the PMF and one-half the PMF were calculated to be 9266 cfs and 4626 cfs, respectively. The flood routings indicate that all floods greater than about 18 percent of the PMF will overtop the dam. A plot of percent PMF versus peak outflow discharge is presented as Plate D-2 in Appendix D.

The spillway and overtop discharge rating curve used in the flood routings was calculated using the weir equation and assuming free overflow across the whole length of the dam and spillway. The spillway is a modified broad-crested weir with a discharge coefficient of 3.2 and the dam crest is a broad-crested weir with a discharge coefficient of 3.1. The reservoir stage capacity curve was determined from U. S. Geological Survey 7.5 - minute topographic maps and data obtained from State files. This stage-capacity curve was extended above the dam crest to include surcharge storage during flood peak

discharges. In the reservoir routing computations possible discharges through the outlet works were excluded because their capacity is small compared to the PMF and because of the possibility that the outlet valves may be closed. The stage-storage and the spillway and overtop stage-discharge curves are presented in Appendix D as Plates D-3 and D-4, respectively.

Because the dam will be overtopped a significant length of time for both the PMF (11.0 hours) and one-half the PMF (7.5 hours), several floods were routed to the community of Millburn 2.7 miles downstream. These routings were used to assess the degree of hazard that would result should the dam fail. The floods were routed downstream through three successive reaches using the HEC-1 program. Estimates of channel shapes, slopes and roughnesses were made based on conditions observed in the field and U. S. G. S. topographic maps. Three different floods were compared in assessing the downstream hazard: (1) the PMF assuming the dam is breached; (2) the PMF assuming the dam is not breached; and (3) the flood that is approximately equal to the existing capacity of the spillway (20% of the PMF).

The breach parameters used in the HEC-1 analysis are: the breach is thirty feet wide at the bottom, has 45-degree side slopes, will extend to the approximate original streambed elevation, will begin breaching when the dam is first overtopped, and will develop to its maximum size in 2.5 hours. These parameters assume the core wall will collapse as the downstream supporting material is erroded and, therefore, will not be effective in resisting breach development. The peak outflow through the breach during the PMF and one-half the PMF was calculted to be 16,284 cfs and 12,374 cfs, respectively. The peak outflow discharge through the breach that results from a flood that just overtops the dam crest (20% of PMF) was computed to be 8699 cfs. This peak outflow and breach size was compared, on the basis of embank-

ment height and reservoir volume, with reported failures of other dams and was found to be reasonable.

The flood depth, width and mean flow velocity of the three floods at a cross-section just inside the community of Millburn are summarized in the following tabulation.

	Flooding Characteristics at the Community of Millburn		
	20% PMF Without Breaching	PMF Without Breaching	PMF With Breaching
Peak Discharge, cfs	1589	9187	15,387
Peak Flood Depth, ft.	4.4	7.6	9.0
Peak Flood Top Width, ft.	280	490	580
Peak Flow Velocity, fps	2.3	4.8	5.8

The drain outlet for Orange Reservoir has its intake at the reservoir floor, is 20-inches in diameter, and about 280 feet in length. Based on field observations and the U.S.G.S. map, the outlet discharges into the downstream spillway channel at an elevation of about 5 feet below the reservoir floor. Assuming no inflows to the reservoir and a constant tailwater elevation 5 feet below the reservoir floor, it is estimated that the outlet can drain the reservoir, from a spillway level full condition, in approximately 11 days.

b. Experience Data

Records of Lake levels are maintained for this site. The reservoir is operated to maintain maximum water levels at all times. There are no reports or evidence that the dam has ever been overtopped.

c. Visual Observations

There is a well defined spillway channel downstream of the embankment that appears to be about 30 feet wide and two

to three feet deep with a levee on the right bank about seven feet high. No dwellings were observed immediately downstream. The flood plane below the dam contains a fairly dense stand of medium and small trees with significant undergrowth (Photo 11).

Just upstream of the reservoir, Northfield Road crosses Rahway River. Available data indicate the bottom elevation of the concrete bridge girder is 330.79 feet MSL. During floods that overtop the dam crest, elevation 330.9 feet MSL, this bridge will be overtopped and back up flood waters. Several structures shown on U.S.G.S. maps as being near the river banks upstream of the bridge will be inundated.

d. Overtopping Potential

As indicated in Section 5.1-a, all floods greater than about 18 percent of the PMF, when routed through the reservoir, will overtop the dam. The PMF and one-half the PMF will overtop the dam by 1.77 feet and 0.94 feet, respectively. These overtopping heights assume the dam remains in its current condition.

A dam breach analysis was made to determine if the existing spillway is Seriously Inadequate because (1) the Spillway Design Flood is the PMF; (2) the spillway is not capable of passing one-half the PMF; and (3) there is a high downstream hazard to loss of life during large flood flows. The results of this analysis are presented in Section 5.1-a. One of the Corps' criteria for classifying a spillway as Seriously Inadequate is, "Dam failure resulting from overtopping would significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure."

The data tabulated in Section 5.1-a were used to assess the degree of significance that overtopping failure would increase the downstream hazard. Under the assumption that

breaching of the embankment begins as soon as the dam is overtopped, the pre-breach discharge at Millburn will be about 1589 cfs (20% PMF), as compared to a breach peak discharge during the PMF of about 15, 387 cfs. The flow depth, top width and velocity will be about double during the breach peak discharge and result in a significantly higher downstream hazard. Under these conditions, the spillway for Orange Reservoir Dam should be classified as Seriously Inadequate.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

At the time of the inspection the dam did not exhibit any visible signs of distress. The downstream embankment is somewhat uneven and is heavily covered with brush and trees

Visual observation indicates that the spillway is in satisfactory condition. Surface peeling and spalling of the concrete apron are not presently severe enough to affect the structural strength or stability but could cause problems if left unchecked.

The outlet works appear to be in satisfactory condition based on visual observations.

b. Design and Construction Data

The available design and construction data are inadequate to evaluate the structural stability, since little is known of design criteria, construction methods or as-built material properties.

c. Operating Records

There is no instrumentation of the dam. The reservoir is essentially uncontrolled except for the withdrawals made by the City. Records of reservoir levels and water withdrawals are reportedly available.

d. Post-Construction Changes

Post-construction changes are described in Section 2. The repairs and modification of the spillway and riprap on the upstream face of the dam appear to be structurally stable. Patching of the right wingwall is needed.

e. Seismic Stability

Since the area lies within Seismic Zone 1, only minor damage may be expected from distant earthquakes. In general, projects located within Seismic Zone 1 may be assumed to present no hazard from earthquakes, provided static stability conditions are satisfactory and conventional safety margins exist. Although the dam appears to have adequate static stability, a stability analysis is necessary to verify this.

SECTION 7: ASSESSMENT, RECOMMENDATIONS, PROPOSED REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety

The safety of Orange Reservoir Dam is in question because the present spillway has inadequate capacity to pass the Probable Maximum Flood (PMF) without overtopping the dam. The present spillway can pass only about 18% of the PMF. Should the dam be overtopped, the masonry core wall cannot be expected to offer much structural stability if the embankment materials are eroded away.

The safety of the embankment cannot be quantitatively analyzed due to lack of available data. However, visual inspection indicates that the embankment is in good condition with no noticeable seepage and no evidence of major stress, settlement, or cracking. In addition, the outlet works appear to be in satisfactory condition.

b. Adequacy of Information

The information and data obtained are not adequate to perform a comprehensive, definitive evaluation of the dam's structural stability.

c. Urgency

The visual inspection revealed no apparent deficiencies that would imperil the short term integrity of the structure.

The hydrologic analysis indicates that the spillway is seriously inadequate. Therefore, studies to augment the spillway discharge capacity should be made soon.

The owners should plan and implement a warning system whereby inhabitants downstream of the dam could be evacuated should

overtopping of the dam appear imminent. Planning of this system should be very soon and the system should be implemented in the near future.

Field and laboratory investigations should be performed in the near future to determine physical properties of the embankment and foundation materials.

d. Necessity for Additional Data/Evaluation

At the present time there is insufficient information available to fully evaluate the structural stability of the dam. The Corps of Engineers Guidelines require that, in general, seepage and stability analyses should be on record for all dams in the high hazard category. A program of borings should be performed to confirm the materials, including testing of the puddle, installation of piezometers to establish internal water levels in the downstream slope and an evaluation should be conducted by an experienced geotechnical engineer. The piezometers should be permanent and read periodically. The field investigation should begin in the near future and the evaluation performed soon after completion of the field work and testing. In addition, the dam should be surveyed in the near future to confirm the as-built geometry of the dam.

7.2 Remedial Measures

a. Alternatives

The alternatives available for increasing the spillway capacity are:

1. Increase the height of the dam, thus increasing the storn surcharge.
2. Increasing the height of the dam and increasing the size of the spillway.
3. Lower the level of the reservoir, thus providing a flood control pool.
4. Any combination of 1 and 3, or 2 and 3.

b. Operation and Maintenance Procedures

A program of annual inspections of the dam should be initiated by the owners, utilizing the standard visual check-list in this report. The peeling and spalling of the spill-way apron should be carefully observed, and remedial work performed should the deterioration continue. The area of potential slope instability located on the left bank of the reservoir approximately 300 ft. upstream at the spill-way also warrants close inspection.

A permanent record should be kept of all maintenance and operating events of the dam and reservoir.

The roots of the trees growing along the crest of the dam may be causing damage to the core wall. In addition, the crest of the dam could be significantly damaged should these trees be blown down during a storm. Therefore, it is recommended that the trees along the crest of the dam should be cut flush with the surface of the dam and removed

All brush and small trees should be removed from the downstream face of the dam soon in order to facilitate inspection of the embankment and prevent root damage. Clearing of the downstream face should continue as standard maintenance procedure.

The stones dislodged from the upstream section of the right spillway wing wall should be replaced as soon as possible.

A warning system should be established whereby down-stream inhabitants may be notified and evacuated in the event of possible dam failure.

PLATES

PLATE I

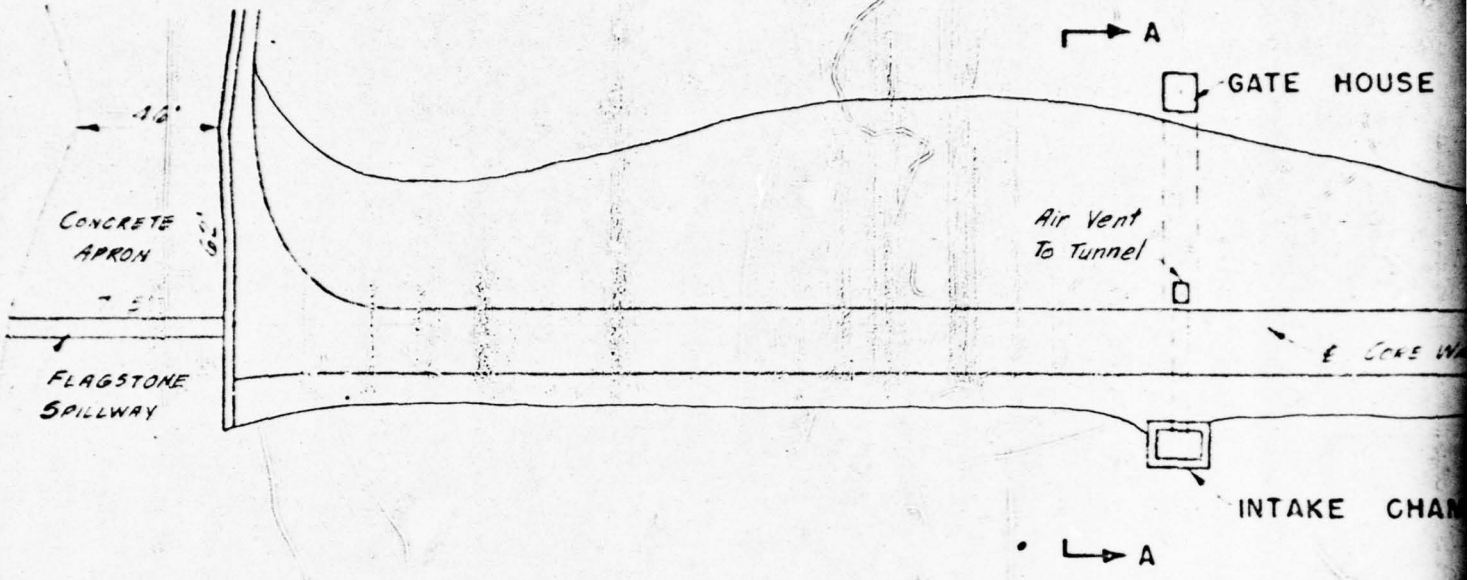
1000 0 1000 2000 3000 4000 5000 6000

SCALE IN FEET

QUADRANGLE LOCATION

VICINITY MAP

JENNY/LEEDSHILL DECEMBER 1978



PLAN OF DA

SCALE : 1" = 50'

Form 6—IX—

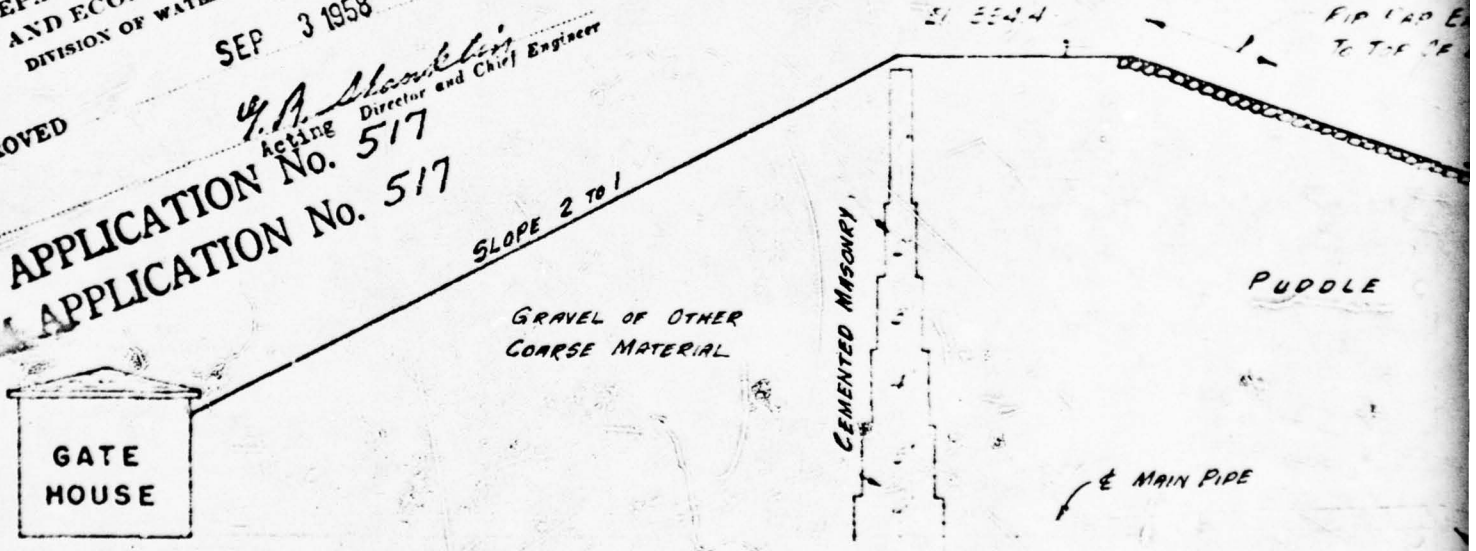
DEPARTMENT OF CONSERVATION
AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY

APPROVED SEP 3 1958

Acting Director and Chief Engineer

DAM APPLICATION No. 517

DAM APPLICATION No. 517



SECTION A-A

SCALE : 3/32" = 1'-0"

PLATE 2

SHEET No. 2 OF 3

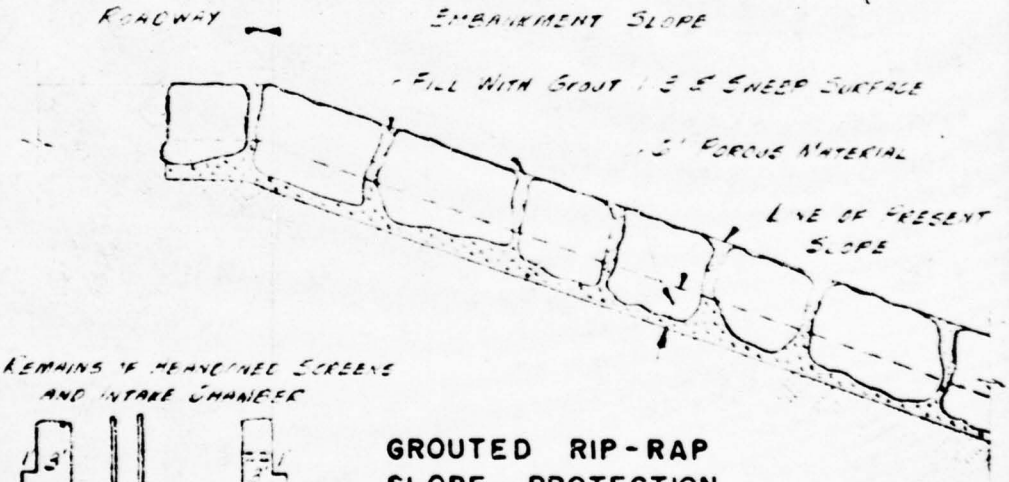
SE

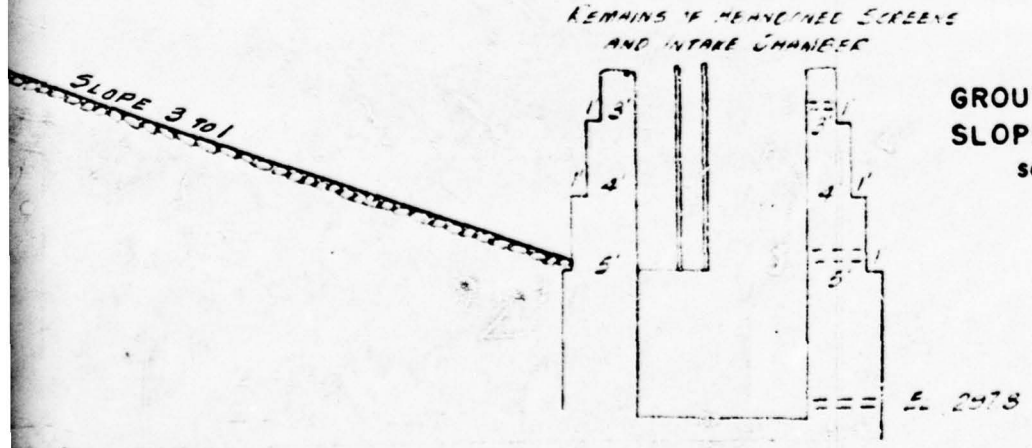
E WALL

CHAMBER

DAM

AP EXTENDED
OF DAM





GROUTED RIP-RAP
SLOPE PROTECTION
SCALE: 1/2" = 1'-0"

& WASTE PIPE

IMPROVEMENTS & REPAIRS
PLAN & DAM SECTION
ORANGE RESERVOIR
SOUTH MOUNTAIN RESERVATION

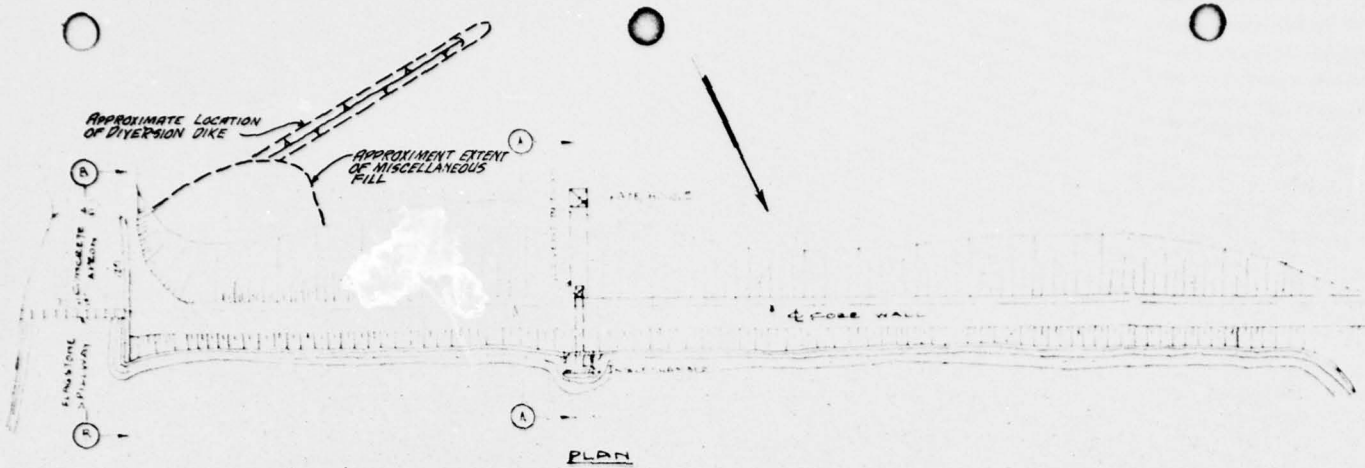
CITY OF ORANGE, N.J.

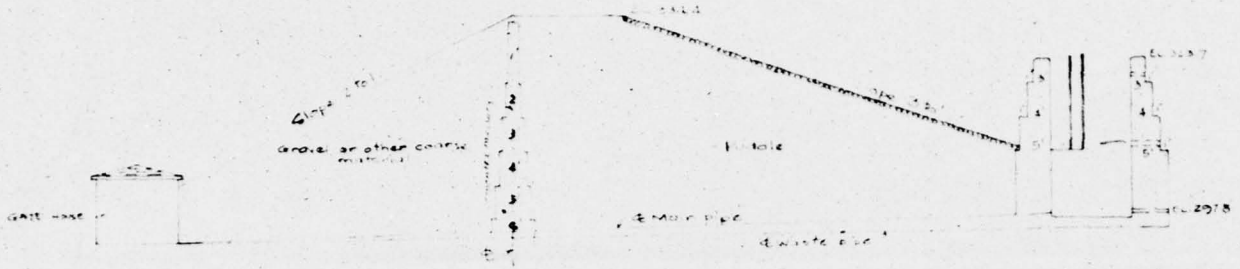
CLYDE POTTS ASSOCIATES
CONSULTING ENGINEERS
203 PARK AVE. PLAINFIELD, N.J.

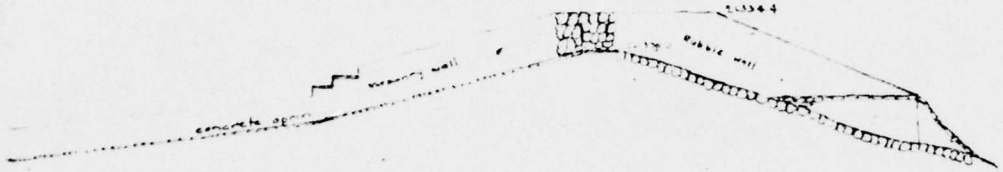
SCALE: AS SHOWN

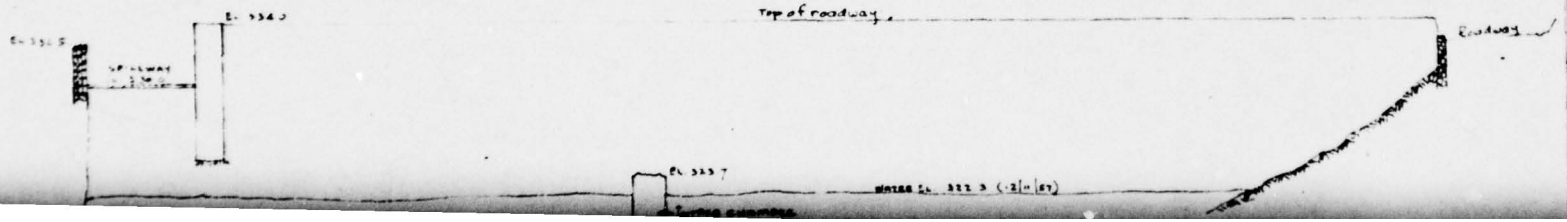
JULY 1958

2


APPROXIMATE LOCATION OF DIVERSION DIKE
APPROXIMENT EXTENT OF MISCELLANEOUS FILL
FLOODWALL
CLOSURE WALL
PLAN

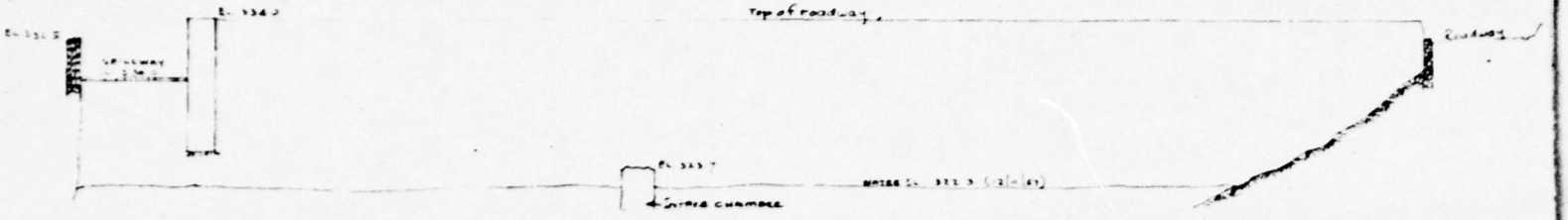

gravel or other coarse material
gate house
existing pipe
SECTION A-A


rubble wall
concrete deck
SECTION B-B

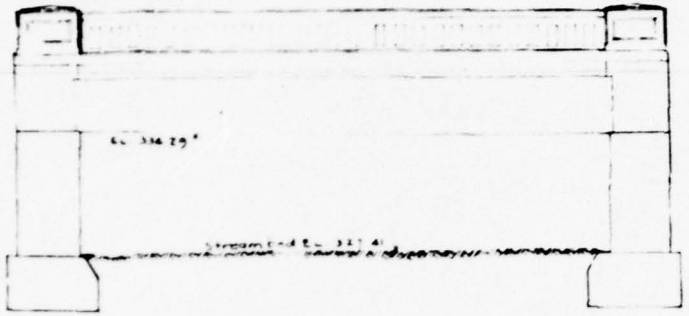

Top of roadway
Roadway
WATER EL. 323.3 (2/11/67)

SECTION B-B

SCALE 1" = 10'



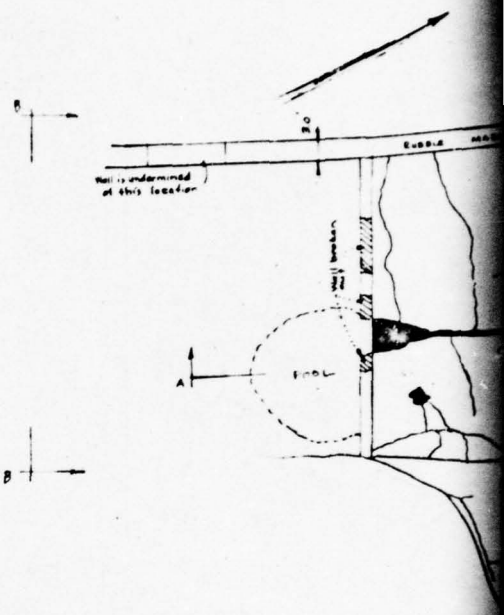
ELEVATION AT DAM LOOKING DOWNSTREAM



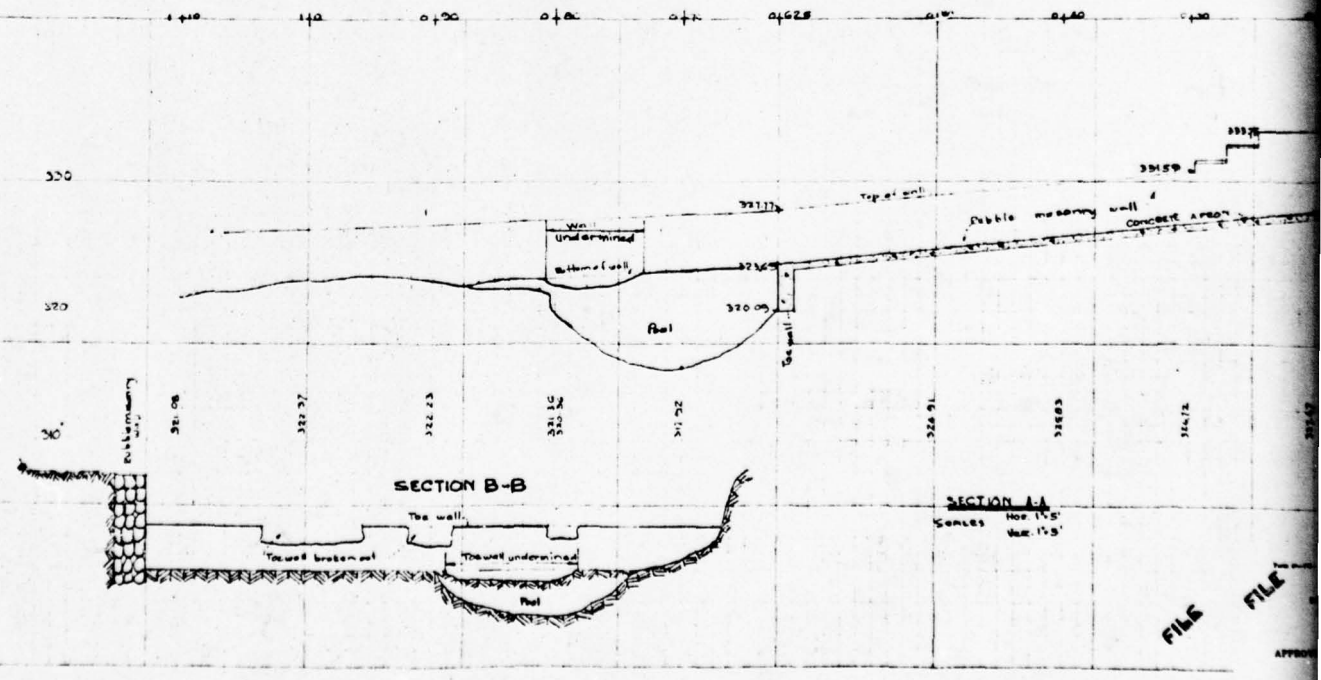
ELEVATION AT NORTHFIELD AVE. BRIDGE LOOKING UPSTREAM

OFFICE OF CITY ENGINEER
CITY OF ORANGE, N.J.
RESERVOIR NO. 1 - DETAILS OF
DAM AND BRIDGE AT NORTHFIELD AVE.
SCALES AS SHOWN DECEMBER 1957

PLATE 3



RECEIVED



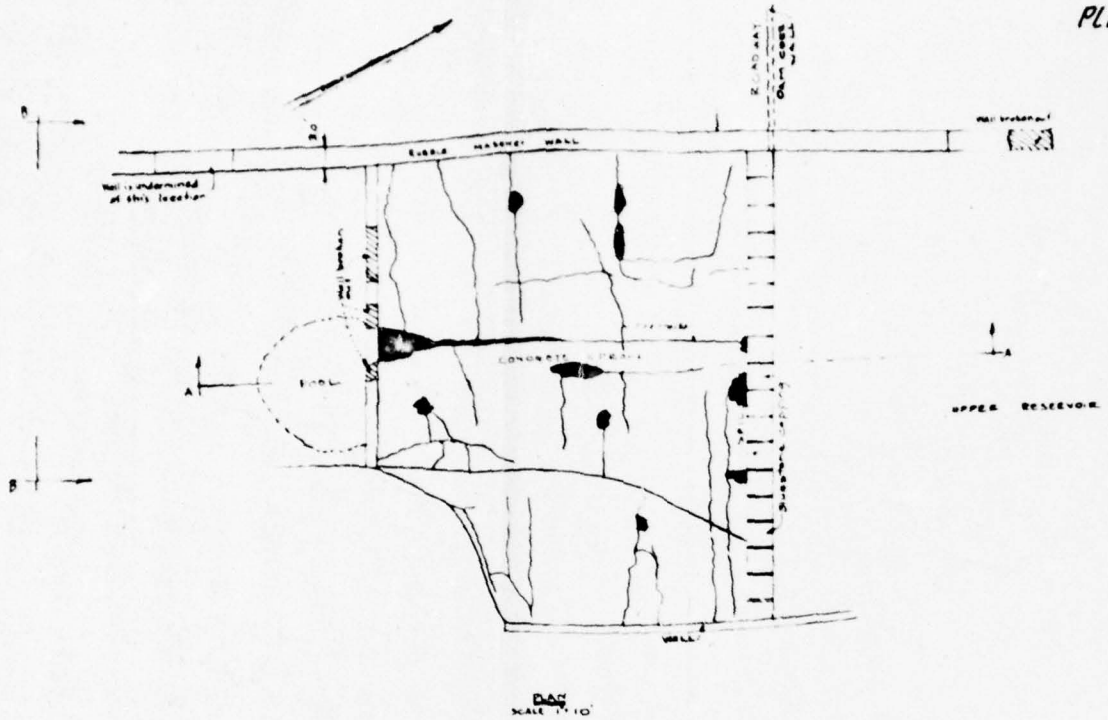
FILE

FILE

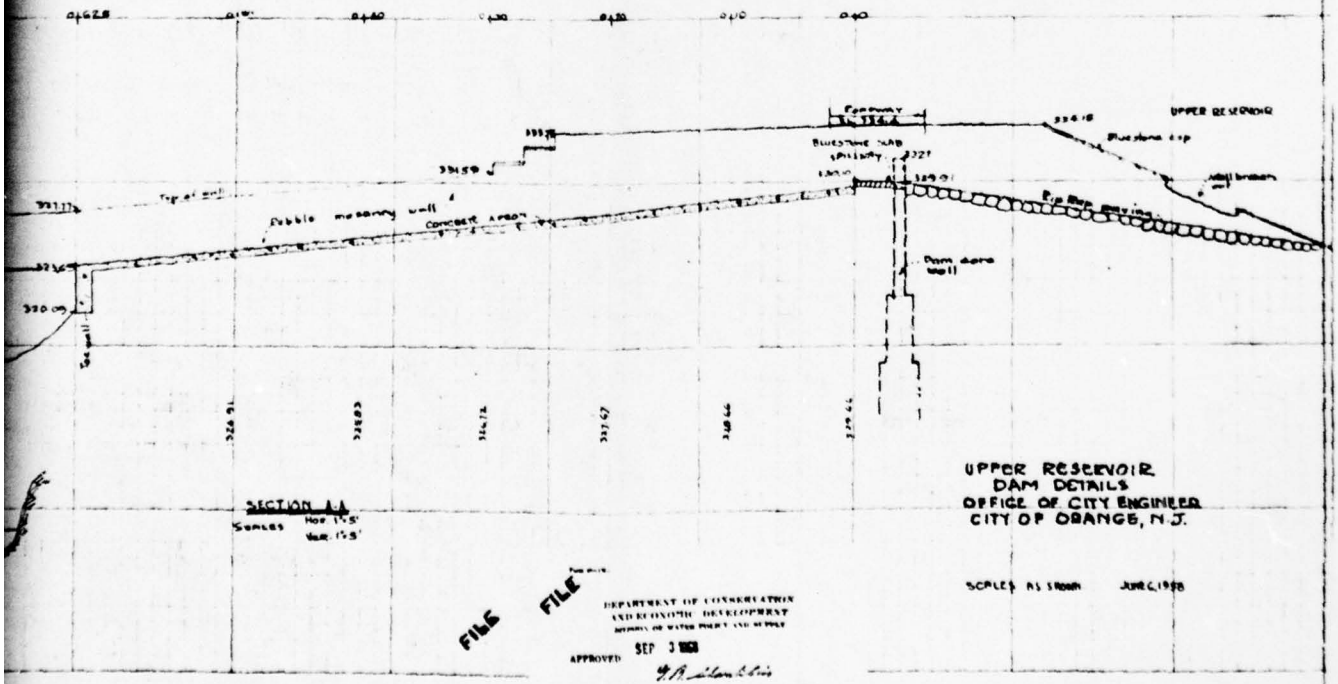
DAM AP

DAM AP

PLATE 4



DAM
SCALE 1" = 10'



SECTION A-A
Scales Hor. 1"=5'
Ver. 1"=5'

UPPER RESERVOIR
DAM DETAILS
OFFICE OF CITY ENGINEER
CITY OF ORANGE, N.J.

SCALES AS SHOWN JUNE, 1938

FILE FILE

DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY

APPROVED SEP 3 1958

DAM APPLICATION No. 517

DAM APPLICATION No. 517

2

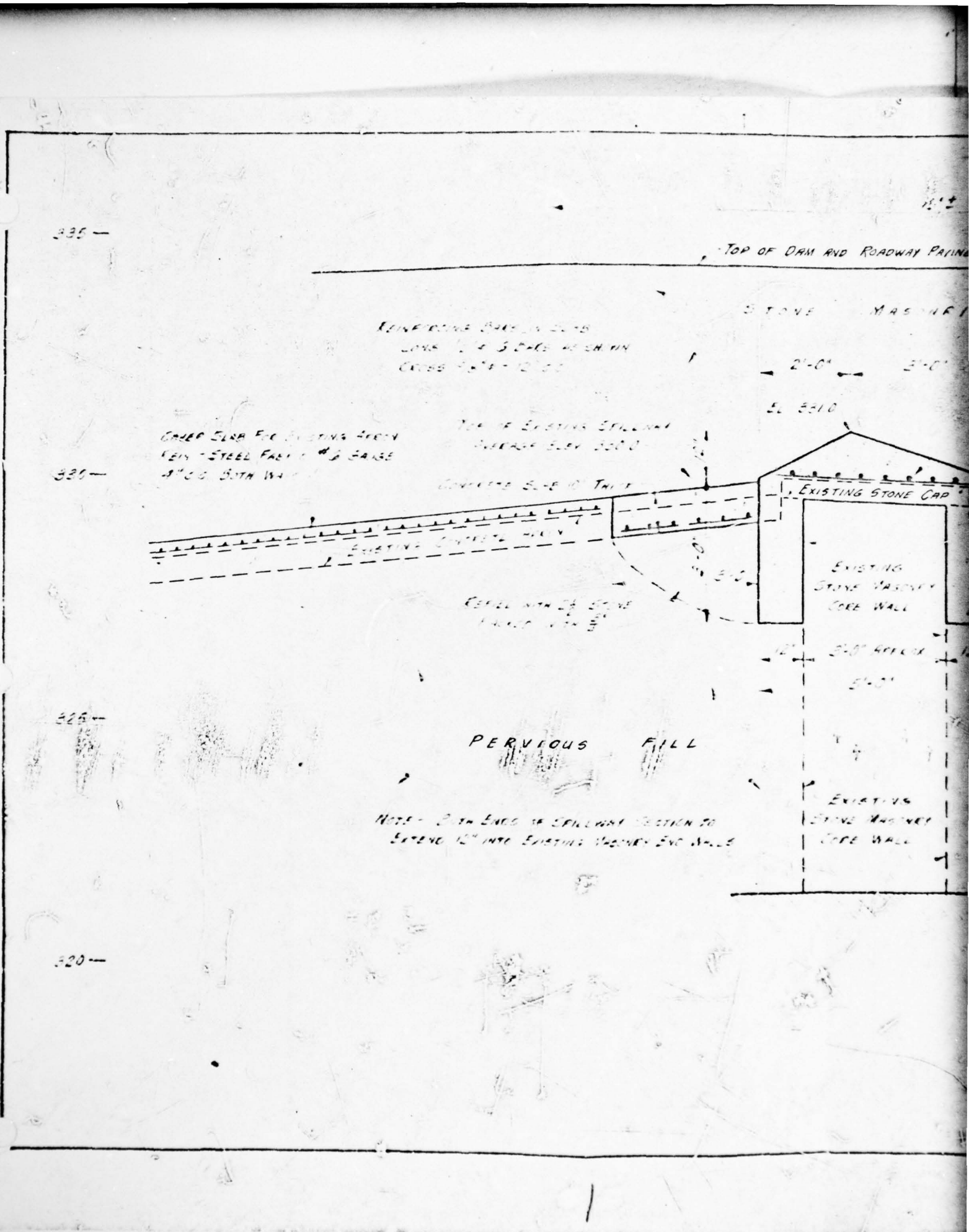
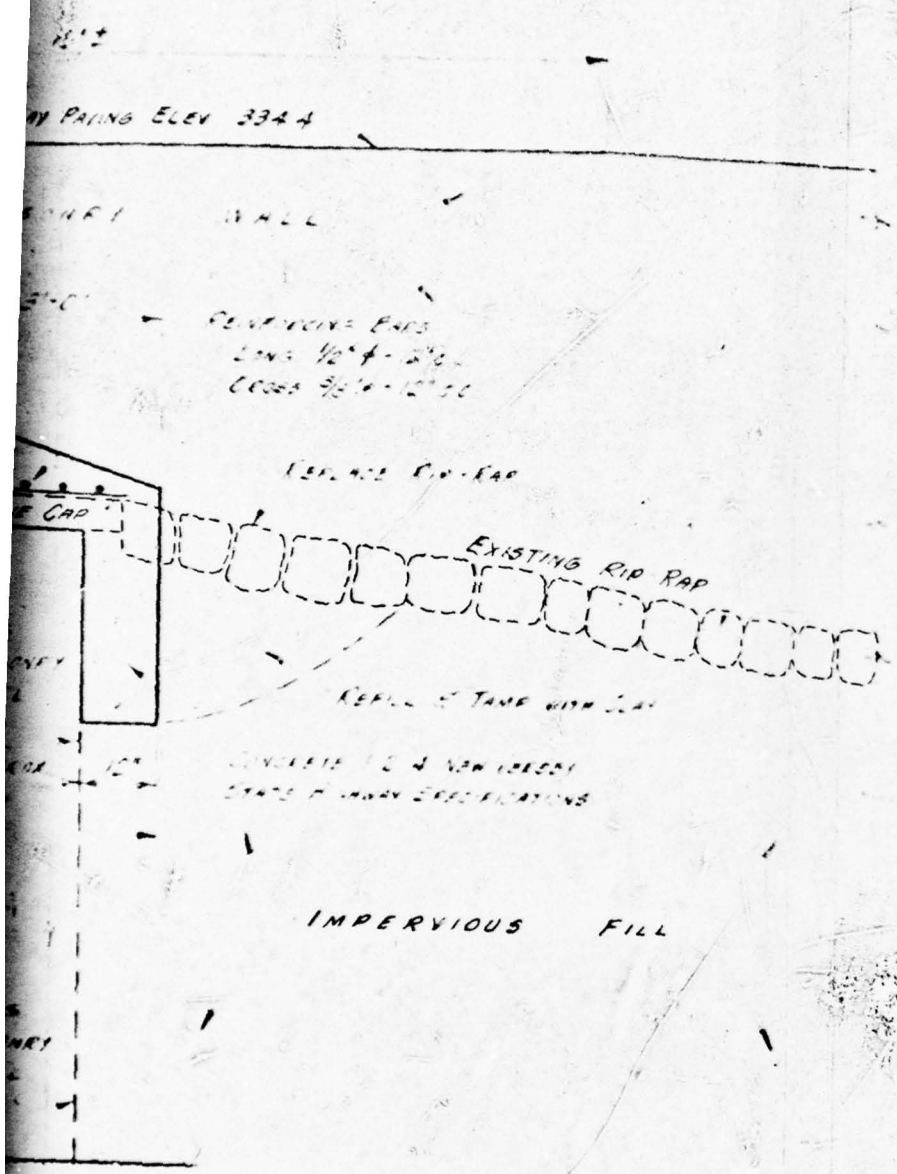

335
330
325
320
TOP OF DAM AND ROADWAY PAVING
STONE MASONRY
2'-0"
3'-0"
EL 324.0
EXISTING STONE CAP
EXISTING STONE MASONRY CORE WALL
EXISTING STONE MASONRY CORE WALL
PERVIOUS FILL
NOTE - SIDE ENDS OF SPILLWAY SECTION TO EXTEND 12" INTO EXISTING MASONRY END WALLS

PLATE 5

SHEET NO 1 OF 3



DEPARTMENT OF CONSERVATION
AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY

APPROVED SEP 3 1958

Director and Chief Engineer

DAM APPLICATION No. 517

DAM APPLICATION No. 517

FILE

FILE

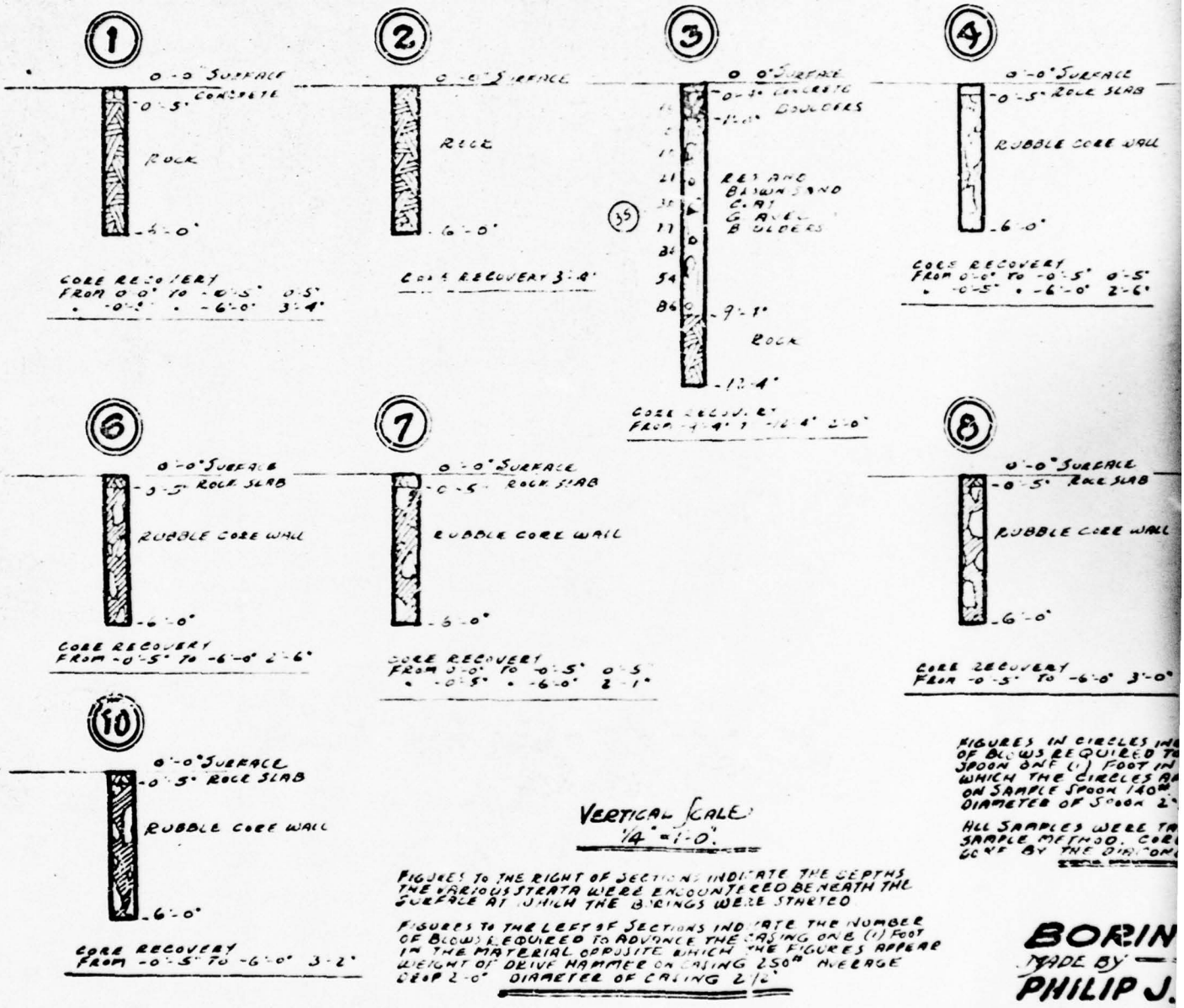
IMPROVEMENTS & REPAIRS
TYPICAL SECTION
FIXED RAISING OF SPILLWAY (1'-0")
ORANGE RESERVOIR
SOUTH MOUNTAIN RESERVATION

CITY OF ORANGE, N.J.

SCALE 1/2" = 1'-0"

JULY 1958

CLYDE POTTS ASSOCIATES
CONSULTING ENGINEERS
203 PARK AVE. PLAINFIELD, N.J.



VERTICAL SCALE
1/4" = 1'-0"

FIGURES TO THE RIGHT OF SECTIONS INDICATE THE DEPTHS THE VARIOUS STRATA WERE ENCOUNTERED BENEATH THE SURFACE AT WHICH THE BORINGS WERE STARTED

FIGURES TO THE LEFT OF SECTIONS INDICATE THE NUMBER OF BLOWS REQUIRED TO ADVANCE THE CASING ONE (1) FOOT IN THE MATERIAL OPPOSITE WHICH THE FIGURES APPEAR WEIGHT OF DRIVE HAMMER ON CASING 250# AVERAGE DROP 2'-0" DIAMETER OF CASING 2 1/2"

FIGURES IN CIRCLES IN
OF BLOWS REQUIRED T
SPOON ONE (1) FOOT IN
WHICH THE CIRCLES AR
ON SAMPLE SPOON 140#
DIAMETER OF SPOON 2"

ALL SAMPLES WERE TA
SAMPLE METHOD. CORE
DONE BY THE DIAMOND

BORIN
MADE BY
PHILIP J.
207 BALDWIN
11 PARK PLA
THE MAKING OF BO

6200.

MAY 27 1958

(5)

0'-0" SURFACE
-0'-6" ROCK SLAB
RUBBLE CORE WALL
-6'-0"

CORE RECOVERY
FROM 0'-0" TO -0'-6" 0'-6"
" -0'-6" " -6'-0" 3'-4"

(9)

3'-0" SURFACE
-0'-5" ROCK SLAB
RUBBLE CORE WALL
-6'-0"

CORE RECOVERY
FROM -0'-5" TO -6'-0" 3'-6"

ES INDICATE THE NUMBER
ED TO ADVANCE THE SAMPLE
T IN THE MATERIAL OPPOSITE
ES ROCKER WEIGHT OF HAMMER
FROM AVERAGE DROP 30"
H 2"

E TAKEN BY THE DRY
CORE DRILLING WAS
MOND DRILL METHOD

INGS

J. HEALEY, INC.,
IN AVE., JERSEY CITY 6.
PLACE · NEW YORK 7.

F BORINGS IS OUR ONLY BUSINESS

RESERVOIR.

ACCESS ROAD
RUBBLE WALL
22'-6"
30'-7"
#10
#8
#9
#7
#6
#4
#5
#2
#1
#3
0'-5"
4'
4'
RUBBLE WALL
30'-9"
31'-10"
4'-2"
0'-5"
3'
71'-5"
1'-3"
BROWNSTREET

INDICATES ◎ BORINGS

PLOT PLAN.
NOT TO SCALE.

SKETCH SHOWING PLAN & CROSS-SECTIO.
OF
DIAMOND DRILL BORINGS
MADE FOR
CITY OF ORANGE, NEW JERSEY
ORANGE RESERVOIR · SOUTH ORANGE RESER
ORANGE · NEW JERSEY.

CLYDE POTTS ASSOCIATES
CONSULTING ENGINEERS
203 PARK AVENUE, PLAINFIELD

PURCHASE ORDER NO. 18671

2

View of intake structure. (Nov. 14, 1949)

APPENDIX A

CHECK LIST - VISUAL OBSERVATIONS

CHECK LIST - ENGINEERING, CONSTRUCTION
MAINTENANCE DATA

Check List
Visual Inspection
Phase 1

Name Dam Orange Reservoir Dam County Essex State New Jersey Coordinates Lat. 40° 40' 22" N Long. 74° 53' 18" W

Date(s) Inspection Dec. 2 & 16, 1978 Jan 4, 1979 Weather Clear Temperature 35°

Pool Elevation at Time of Inspection 327.5 ft. M.S.L. Tailwater at Time of Inspection 295 ft. (Approx.) M.S.L.

Inspection Personnel:

(December 2, 1978)	(December 16, 1978)	(Jan. 4, 1979)
R. C. Gaffin	D. J. Lachel	R. J. Jenny
A. R. Slaughter		F. L. Panuzio
P. L. Wagner		A. R. Slaughter

Jenny-Leedshill Recorder

Owner Representative
(December 2, 1978)
Frank Zarillo, City of Orange (Maintenance)
Interviewed Mr. A. Maruchii at City of Orange, Public Works Department, December 6, 1978

CONCRETE/MASONRY DAMS

(None)

Orange Reservoir

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEEPAGE OR LEAKAGE	Not Applicable	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Not Applicable	
DRAINS	Not Applicable	
WATER PASSAGES	Not Applicable	
FOUNDATION	Not Applicable	

Orange Reservoir

CONCRETE/MASONRY DAMS

None

VISUAL EXAMINATION OF	OBERSVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Not Applicable	
STRUCTURAL CRACKING	Not Applicable	
VERTICAL AND HORIZONTAL ALIGNMENT	Not Applicable	
MONOLITH JOINTS	Not Applicable	
CONSTRUCTION JOINTS	Not Applicable	

EMBANKMENT

Orange Reservoir

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Downstream slope has minor, local erosion and uneven surface.	Some of the uneven slope may be due to minor differential settlement.
VERTICAL AND HORIZONTAL ALINEMENT OF THE CREST	No apparent movement	
RIPRAP FAILURES	None	Cemented masonry riprap is in good condition.

EMBANKMENT

Orange Reservoir

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
VEGETATION	Trees planted along crest and natural growth of grass and small trees on downstream slope.	Smaller trees and all brush should be removed.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Miscellaneous soil and trash fill has been placed on the downstream face of the dam adjacent to the spillway. Placing of this fill reportedly began about 30 years ago.	
ANY NOTICEABLE SEEPAGE	None	
STAFF GAGE AND RECORDER	Reservoir level is reportedly measured but no gage or recorder were observed.	
DRAINS	None	

OUTLET WORKS

Orange Reservoir

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	No significant cracking or spalling of the 9 ft. diameter brick and masonry tunnel (through which the outlet pipes pass) was observed. Tunnel was inaccessible and was not inspected.	
INTAKE STRUCTURE	Submerged masonry structure not visible at time of inspection. Cannot be inspected.	
OUTLET STRUCTURE	Outlet pipes, valves and structures housing same appear to be in good condition. Two feet of water standing in outlet tunnel, submerging pipes but not valves. Occasional water dripping heard but not observed.	
OUTLET CHANNEL	20-in. diameter emergency outlet pipe empties into a small stilling pond and then flows through dike into natural, heavily wooded channel.	
EMERGENCY GATE	20 in. diameter emergency outlet	Last operated in Summer, 1977.

UNGATED SPILLWAY

Orange Reservoir

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Reinforced concrete sill, triangular in cross-section, added on top of original crest in 1958. Good condition; no cracking or spalling observed.	
APPROACH CHANNEL	Minor debris consisting of grass and twigs.	
DISCHARGE CHANNEL	Reinforced concrete apron in good condition with only minor surface spalling and peeling. Approximately 7 feet deep pool at downstream toe of apron.	Areas of peeling and spalling should be inspected regularly. If deterioration of concrete continues, repair with epoxy cement may be required.
BRIDGE AND PIERS	Some stones dislodged from upstream section of the west wing wall. The masonry wing wall along the left abutment does not extend along the downstream section of the concrete apron and minor erosion of the left abutment has occurred in this area.	Dislodged stones should be replaced in the wing wall. The left abutment adjacent to the downstream section of the spillway concrete apron should be inspected regularly to detect any additional erosion. If erosion continues, the wing wall should be extended downstream for the length of the apron.

GATED SPILLWAY
(None)

Orange Reservoir

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	Not Applicable	
APPROACH CHANNEL	Not Applicable	
DISCHARGE CHANNEL	Not Applicable	
BRIDGE AND PIERS	Not Applicable	
GATES AND OPERATION EQUIPMENT	Not Applicable	

INSTRUMENTATION

Orange Reservoir

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER	None	

RESERVOIR

Orange Reservoir

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	-The immediate slopes are gentle with locally steep slopes in the vicinity of the left abutment of dam. -Heavily wooded. -Masonry riprap is placed along the perimeter of the reservoir and is in good condition, except for a break ±25 ft. long, approx. 300 ft. upstream from the left abutment of the dam.	Collapsed section of riprap should be replaced.
SEDIMENTATION	Reservoir appears clear. No evidence that sedimentation is a problem. Emergency outlet reportedly used to remove sediments.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	- Heavily wooded, natural channel - Approx. 7 ft. high, dumped rock dike is present on west side of spillway channel.	
SLOPES	Broad flat channel immediately downstream with steep side slopes	
APPROXIMATE NO. OF HOMES AND POPULATION	None visible from dam. Maps indicate densely populated area downstream.	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

Orange Reservoir

ITEM	REMARKS
PLAN OF DAM	- Plan and Section of dam shown on Sheet 2 of 3, titled 'Improvements & Repairs, Plan and Dam Section Orange Reservoir, South Mountain Reservation', dated July 1958, included with Report of Dam Application No. 517. (Plates 2 and 3 of this report)
REGIONAL VICINITY MAP	- Dam and Reservoir are shown on U.S. Geological Survey, Caldwell Quadrangle (Scale 1:24,000) Part of the downstream channel shown on the Roselle Quadrangle (Plate 1)
CONSTRUCTION HISTORY	- No available data regarding original construction. Application for Permit for Stream Encroachment dated February 19, 1958 notes dam was constructed in 1833. Owner's representative reported the dam was constructed in 1883.
TYPICAL SECTIONS OF DAM	See 'Plan of Dam'.
HYDROLOGIC/HYDRAULIC DATA	Design flood flow using 150% Central Jersey Curve and spillway capacity for the raised spillway were included in Report of Dam Application No. 517.
OUTLETS - PLAN	
- DETAILS	Plan and details shown on same drawing showing plan and section of dam.
-CONSTRAINTS	None available.
-DISCHARGE RATINGS	None available.
RAINFALL/RESERVOIR RECORDS	Reservoir levels reportedly available at Chestnut Street filter plant.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
(CONTINUED)

Orange Reservoir

ITEM	REMARKS
DESIGN REPORTS	Original design reports are not available. Design report regarding spillway modification was submitted by Clyde Potts Associates, dated February 19, 1958.
GEOLOGY REPORTS	None available.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available. See 'Hydrologic/Hydraulic Data'. None available. None available.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Ten post-construction boring logs at spillway are available. Submitted with letter from Clyde Potts Associates, dated July 28, 1958. None available. None available.
POST-CONSTRUCTION SURVEYS OF DAM	Post-construction survey of spillway only is available. Survey presented on drawing submitted with letter from Clyde Potts Associates, dated July 28, 1958.
BORROW SOURCES	Unknown.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

(CONTINUED)

Orange Reservoir

ITEM	REMARKS
SPILLWAY-PLAN -SECTIONS -DETAILS	Plan, section and details shown on drawings submitted with Report on Dam Application No. 517, approved August 26, 1958. (Plates 3 thru 5)
OPERATING EQUIPMENT PLANS & DETAILS	None available.
MONITORING SYSTEMS	None available.
MODIFICATIONS	Spillway was raised 1 ft. in 1958. Plans, sections, details and specifications are available. (Plate 5)
HIGH POOL RECORDS	Reportedly available at Chestnut Street filter plant.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Engineering report from Clyde Potts Associates dated February 19, 1958 regarding spillway modification.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	No known reports of prior accidents or failure of dam.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

Orange Reservoir

(CONTINUED)

ITEM	REMARKS
MAINTENANCE OPERATION RECORDS	None available.

APPENDIX B

Photographs

(Note: All photographs were taken Dec. 2, 1978)

Photo 1 - View showing central section of the downstream face of dam.

Photo 2 - View looking towards the downstream left abutment of dam showing mixed fill, spillway diversion dike and spillway channel.

Photo 3 - View of spillway and right wing wall looking northwest.

Photo 4 - View of spillway from downstream.

Photo 5 - View of left abutment from downstream spillway apron.

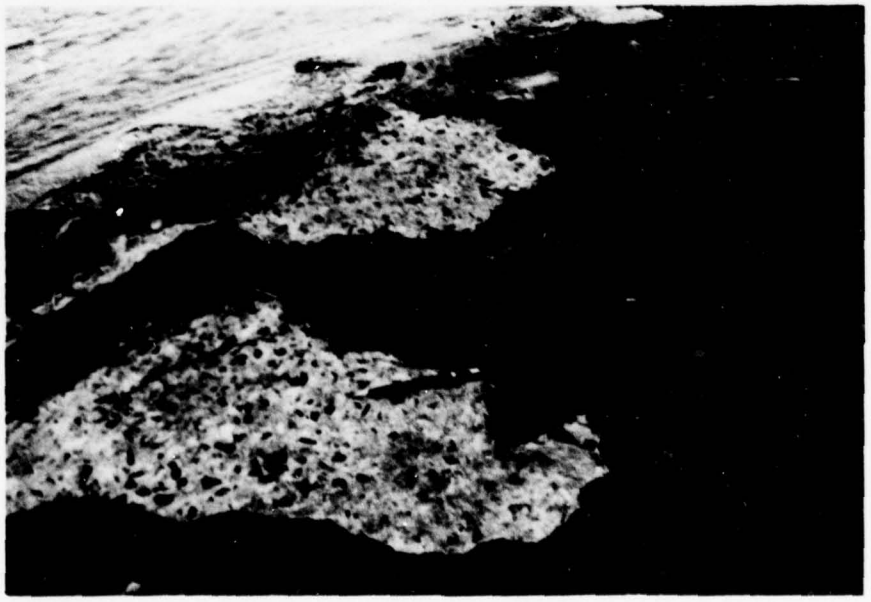


Photo 6 - View of spillway apron showing surface peeling.

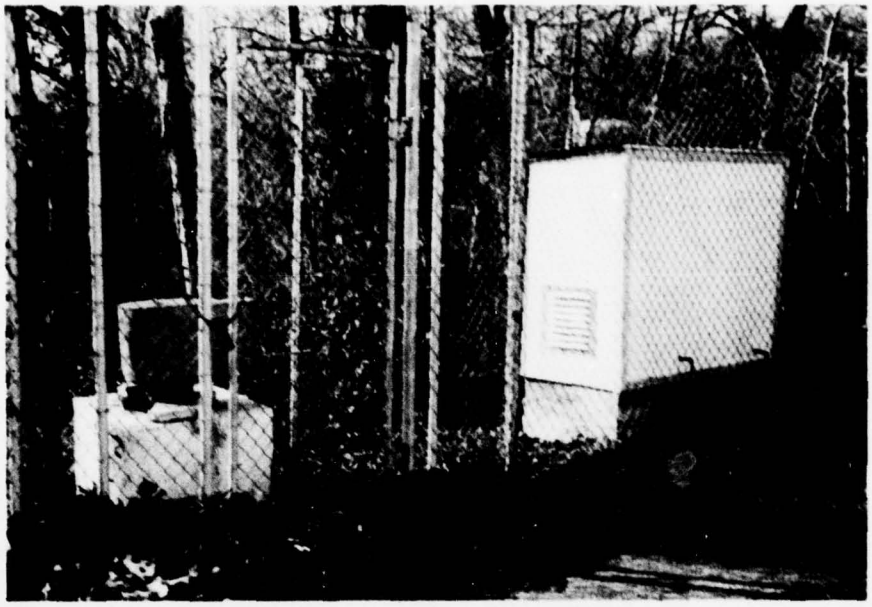


Photo 7 - View showing tunnel vent (left) and aerator compressor (right) at crest of dam.

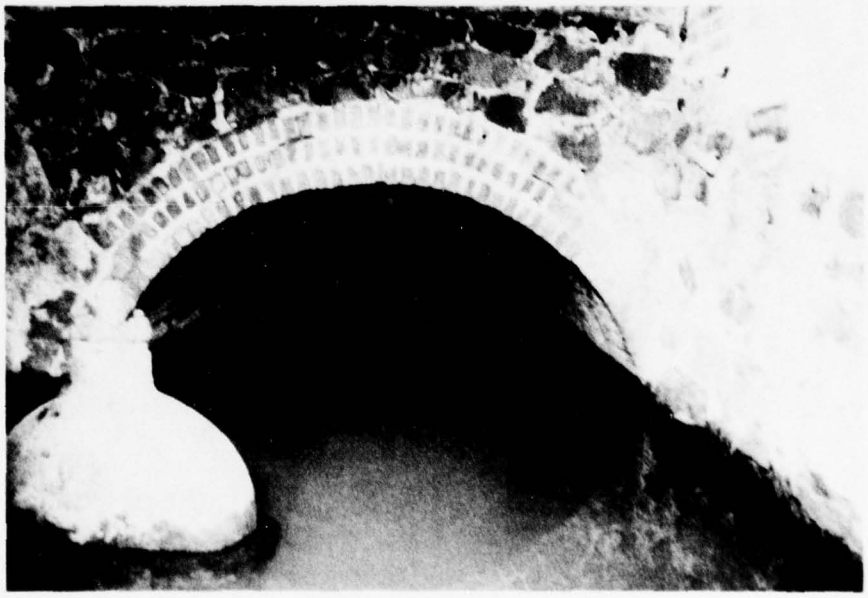


Photo 8 - View of outlet pipes (submerged).

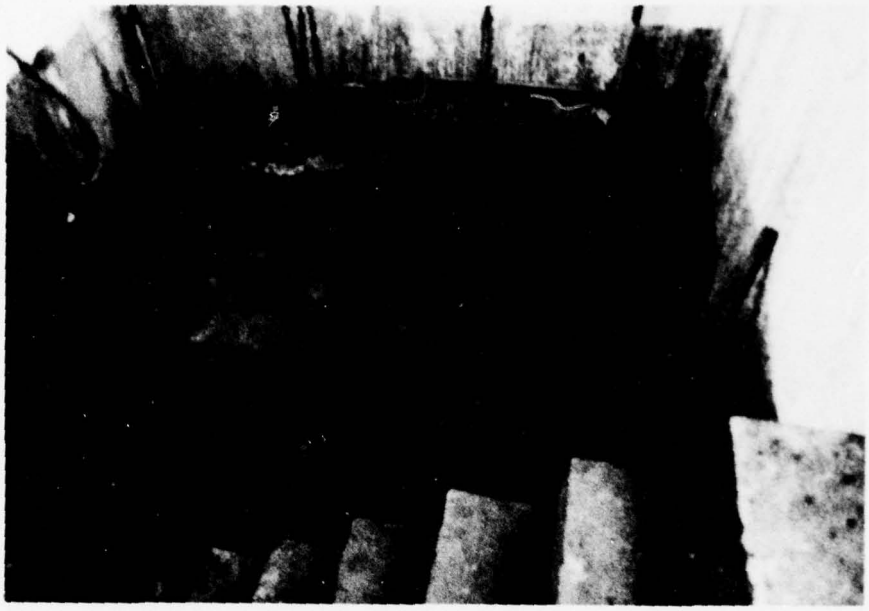


Photo 9 - View of screening chamber.

Photo 10 - View of Northfield Road bridge looking upstream.

Photo 11 - View looking downstream from left (east) side of dam.

APPENDIX C

REGIONAL GEOLOGY - PIEDMONT LOWLANDS

REGIONAL GEOLOGY - PIEDMONT LOWLANDS

Physiography

The Piedmont Lowlands Province of New Jersey lies northwest of a line approximately between Trenton and Perth Amboy and southeast of an approximate line between Milford on the Delaware River and Mahwah near the New York State border. Physiographically, the province is situated between the predominantly Precambrian age New Jersey Highlands Province to the northwest and the typically unconsolidated Creataceous age and younger sediments of the Coastal Plain Province to the southeast. (See Figure C-1].

Bedrock

The Piedmont Lowlands, encompassing about one-fifth of the state, is characterized by northwestward dipping bedrock composed of interbedded red shales, siltstones and sandstones of Triassic and Jurassic age and igneous basalt extrusions (lava flows) and diabase intrusions of Jurassic age. The sedimentary rocks have been eroded to a broad southeastward sloping piedmont plain. The northwest border of the province is a northeast-southwest trending fault zone (Ramapo Fault) which truncates the sedimentary beds. Total vertical displacement on the fault may reach 10,000 feet.

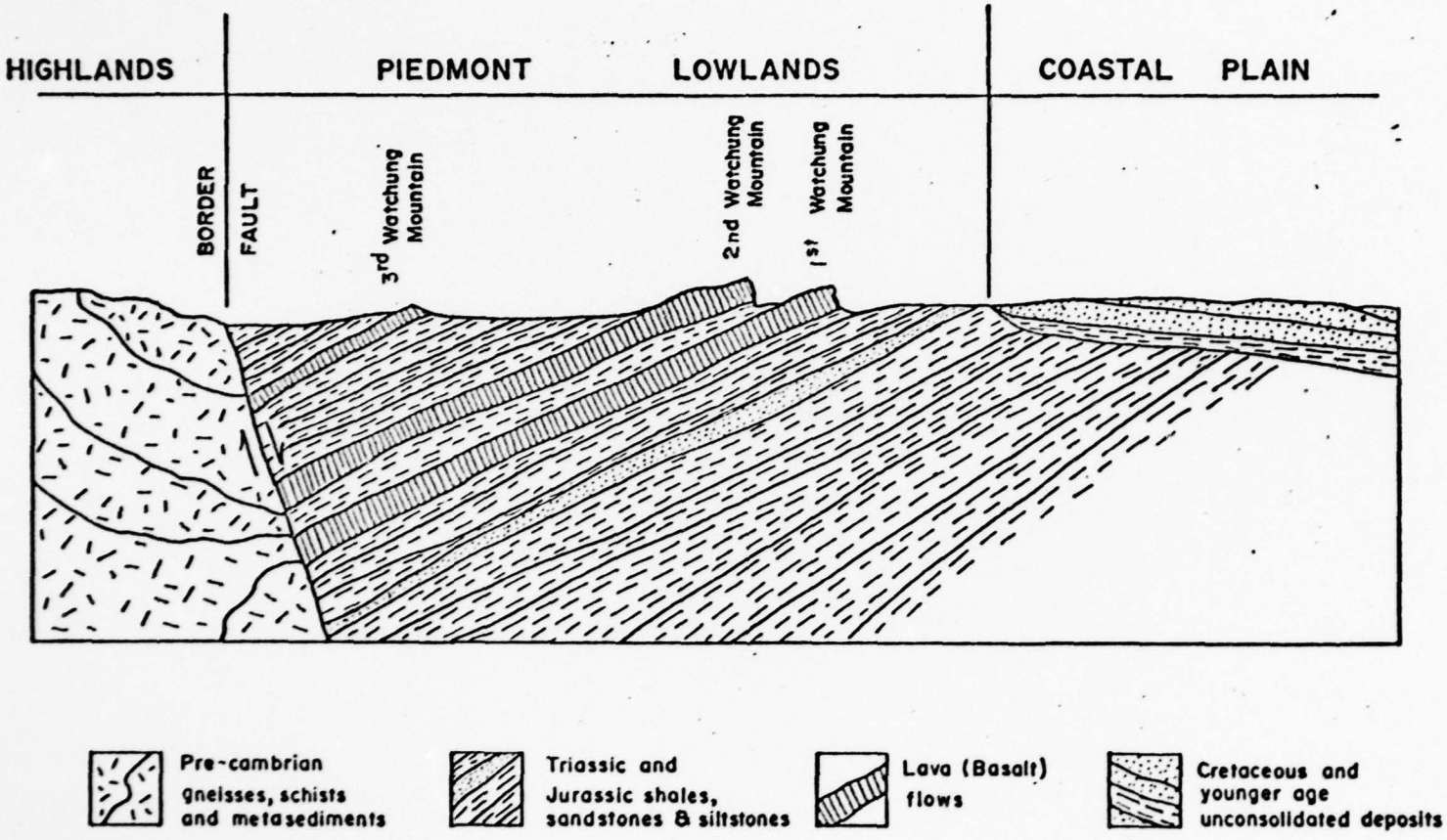
The gently rolling lowland topography of the piedmont lowlands is pierced by long asymetric ridges of hard

and resistant igneous rocks which were intruded into or on top of the sedimentary sequences. With the subsequent erosion of the softer sedimentary rocks, these igneous formations have been left standing, often in bold relief, up to 400 ft. above the surrounding plains. The igneous bodies composed of diabase and basalt form the Palisades along the Hudson River and the three Watchung Mountain ridges of the central Piedmont. The ridges are all steeper on the southeast with gentle dip slopes to the northwest.

Overburden

The Pleistocene Age Wisconsin continental glacier has smoothed and filled approximately the northern half of the province. The terminal moraine of the glacier extends from Perth Amboy to Summit then northwestward to Morris Plains. North of the morainal line the soils characteristically consist of glacial tills overlying the bedrock with scattered overlying stratified outwash deposits. At least three large glacial lakes occupied portions of the area north of the moraine at different periods, resulting in a relatively flat topography composed predominantly of silts and clays.

South of the terminal moraine, most of the overburden consists of alluvial deposits overlying a more highly developed weathered transition zone on top of the bedrock. Some highly weathered tills of pre-Wisconsin glaciation can be found on the top of intervalley ridges. Much of the alluvium is glacial outwash.



SCHEMATIC CROSS-SECTION OF
NEW JERSEY PIEDMONT LOWLANDS
PHYSIOGRAPHIC PROVINCE

JENNY / LEEDSHILL
JANUARY 1979

FIGURE C-1

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 50% open space, 50% developed areas, Elev.: 300' to 620'

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 331.0 feet* (770 acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): none

ELEVATION MAXIMUM DESIGN POOL: 334.14 feet*

ELEVATION TOP DAM: 334.4 feet*

CREST:

a. Elevation 334.4 feet*
b. Type Earth
c. Width 16 feet
d. Length 900 feet
e. Location Spillover Left Abutment (looking downstream)
f. Number and Type of Gates none

OUTLET WORKS:

a. Type Water supply outlet 20-inch dia. pipe reducing to 16-inch dia.
b. Location Near right abutment (looking downstream)
c. Entrance inverts Approximate elevation is 310 feet*
d. Exit inverts Approximate elevation is 295 feet*
e. Emergency draindown facilities 20-inch diameter outlet pipe
Entrance elevation Approx. 300 feet, exit elevation Approx 295 feet*

HYDROMETEOROLOGICAL GAGES: UNKNOWN

a. Type
b. Location
c. Records

MAXIMUM NON-DAMAGING DISCHARGE: Less than 1500 cfs

* Essex County datum (assumed 3.5 feet higher than MSL)

Form 16-40—12-39

Dam Application No....517.....

State of New Jersey
State Water Policy Commission

REPORT ON DAM APPLICATION

To the State Water Policy Commission,
State of New Jersey.

Gentlemen:

The application of THE CITY OF ORANGE

filed February 24, 1958 for approval of plans and for a permit to repair and raise the spillway ~~xxxxxx~~ of a dam known as Orange Reservoir Dam ~~xxxx~~ in West Orange on the West Branch Rahway River tributary to Rahway River in Essex County, New Jersey, has been examined by Steven Dola, Principal Hydraulic ~~Assistant~~ Engineer.

PRINCIPAL FEATURES

Location 26.11.8.2.7	Site inspected May 20, 1958 - S.D.
Purpose of dam water supply	Length of dam 900 feet
Drainage area 4.55 sq. mi.	Elevation of flow line 331
Area of Lake about 60 acres	Capacity of lake 250 Mill. gals. at El. 3
Type of dam Earth dam with concrete core wall	Top width 16 feet
Upstream slope 3 to 1	Downstream slope 2 to 1
Foundation material trap rock under spillway	Max. height About 29 feet feet
Type of spillway Masonry overflow	Length of spillway 71.5 feet
Max. head on spillway 3.14 feet	Q = 1275 sec. ft.
Spillway capacity 1435 sec. ft. = 315	sec. ft. per sq. mi. with Zero freeboard
Estimated ~~unobstructed~~ design flood flow 1275	sec. ft. ~~per sq. mi.~~ = 280 c.s.m. = 150% of Central Jersey Curve
Observed Max. flow = 1090 sec. ft. = 154 c.s.m. at Millburn on July 23, 1945	
Outlets other than spillway 1 "main" pipe & 1 "waste" pipe diameters unknown	

Drawings filed by:
Clyde Potts Associates
203 Park Avenue
Plainfield, New Jersey

It has been found that the site for the dam is suitable and the plans adequate to ensure the construction of a structure which will not be a menace to life or property. It is therefore recommended that the plans be approved and that a permit be issued, subject, however, to the following terms and conditions:—

1. That this permit does not give any property rights, either in real estate or material, nor any exclusive privileges; neither does it authorize any injury to private property nor invasion of private rights, nor any infringement of Federal, State or local laws or regulations, nor does it waive the obtaining of Federal assent, when necessary.

(1) Orange Dam Reservoir is in Zone 6

(2) Drainage area is 4.62 square miles. Use precipitation values for a 10 square mile basin and include Hops Brook Factor 1/

(3) Precipitation values from HMR #33 1/ - see page D-4

200 mi^2, 24 hour precipitation - All Season Envelope
= 22.6 inches

Values For 10 mi^2 Basin:

	6 HR	12 HR	24 HR	48 HR
	113 %	123%	132 %	142%
	25.5"	27.8"	29.8"	32.1"
With 0.8 Hops Brook Factor →	20.4"	22.2"	23.9"	25.7"

1/ As instructed by COE.

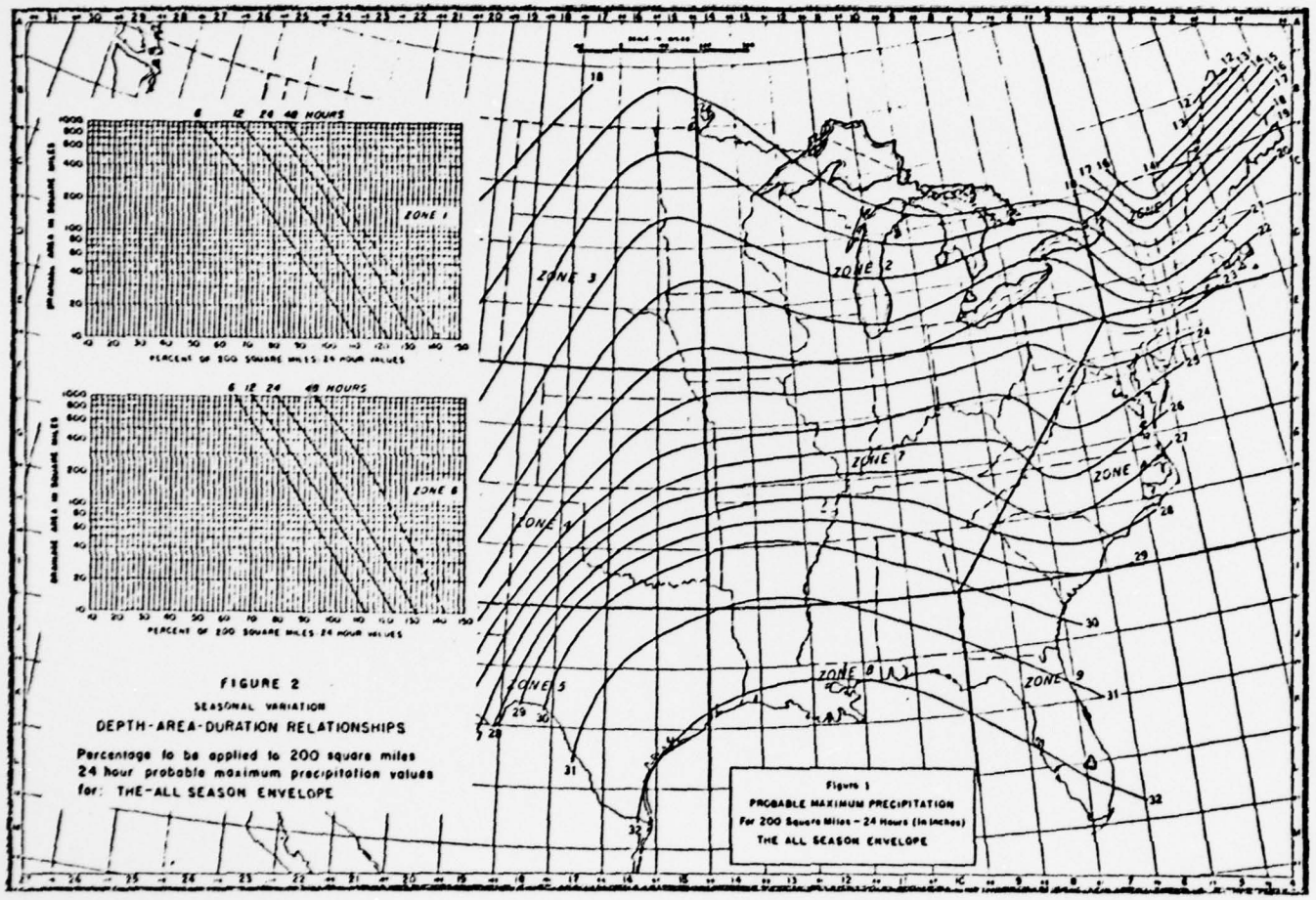


FIGURE 2

SEASONAL VARIATION

DEPTH-AREA-DURATION RELATIONSHIPS

Percentage to be applied to 200 square miles 24 hour probable maximum precipitation values for: THE-ALL SEASON ENVELOPE

Figure 1

PROBABLE MAXIMUM PRECIPITATION

For 200 Square Miles – 24 Hours (In inches)

THE ALL SEASON ENVELOPE

D-4

Tbl 14.12-2 PMP- Orange Dam 302-03

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT n (*continued*)

Type of channel and description	Minimum	Normal	Maximum
C. EXCAVATED OR DREDGED			
a. Earth, straight and uniform			
1. Clean, recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	0.022	0.025
3. Gravel, uniform section, clean	0.022	0.025	0.030
4. With short grass, few weeds	0.022	0.027	0.033
b. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033
3. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. Earth bottom and rubble sides	0.028	0.030	0.035
5. Stony bottom and weedy banks	0.025	0.035	0.040
6. Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. No vegetation	0.025	0.028	0.033
2. Light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. Smooth and uniform	0.025	0.035	0.040
2. Jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. Dense weeds, high as flow depth	0.050	0.080	0.120
2. Clean bottom, brush on sides	0.040	0.050	0.080
3. Same, highest stage of flow	0.045	0.070	0.110
4. Dense brush, high stage	0.080	0.100	0.140
D. NATURAL STREAMS			
D-1. Minor streams (top width at flood stage <100 ft)			
a. Streams on plain			
1. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
2. Same as above, but more stones and weeds	0.030	0.035	0.040
3. Clean, winding, some pools and shoals	0.033	0.040	0.045
4. Same as above, but some weeds and stones	0.035	0.045	0.050
5. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
6. Same as 4, but more stones	0.045	0.050	0.060
7. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
8. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

Main Channel →

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT n (*continued*)

Type of channel and description	Minimum	Normal	Maximum
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
1. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
2. Bottom: cobbles with large boulders	0.040	0.050	0.070
D-2. Flood plains			
a. Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Dense willows, summer, straight	0.110	0.150	0.200
2. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. Same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. Same as above, but with flood stage reaching branches	0.100	0.120	0.160
D-3. Major streams (top width at flood stage >100 ft). The n value is less than that for minor streams of similar description, because banks offer less effective resistance			
a. Regular section with no boulders or brush	0.025	.....	0.060
b. Irregular and rough section	0.035	.....	0.100

Flood Plain →

O-5

The 78/228 Channel Roughness 302-03

Source: V.T. Chow, "Open Channel Hydraulics," 1959.

Thu	790207	Orange Reservoir

Assumed Dam Breach parameters:

Trapezodial breach

30 feet wide at bottom of Breach

45-degree side slopes

Breach to elevation 300 feet

Time to develop maximum breach opening = 2.5 hours.

Assumed parameter are based on previous studies of actual dam failures.

① Relatively high percentage of area is developed but mostly on the steeper slopes.

② Main valley has relatively mild slopes.

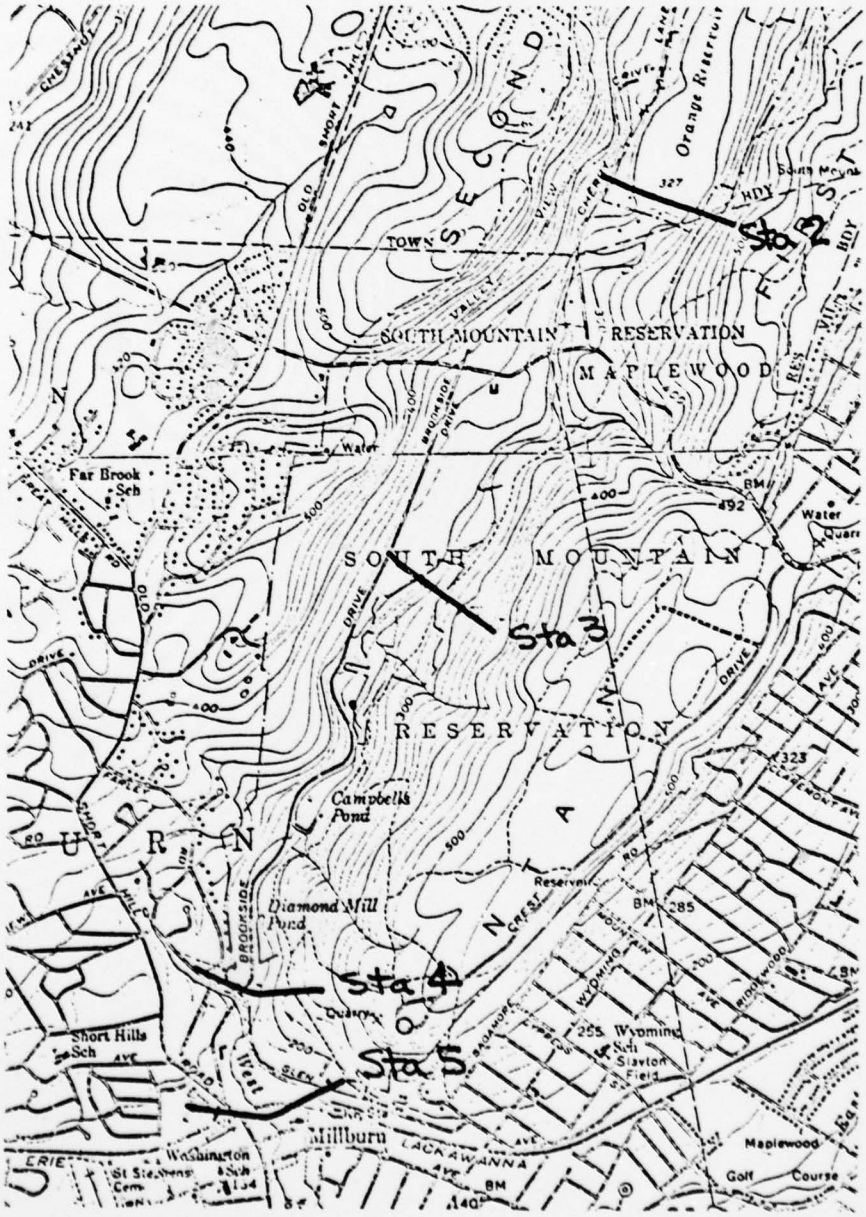
Range of values to use as instructed by COE :

Initial Loss	Final Loss Rate
0.5" to 1.5"	0.05"/hr. to 0.15"/hr.

Use: Initial loss Rate - 1.0 inch
Final Loss Rate - 0.10 inches/hour

Thu 790207	Orange Reservoir	302-03

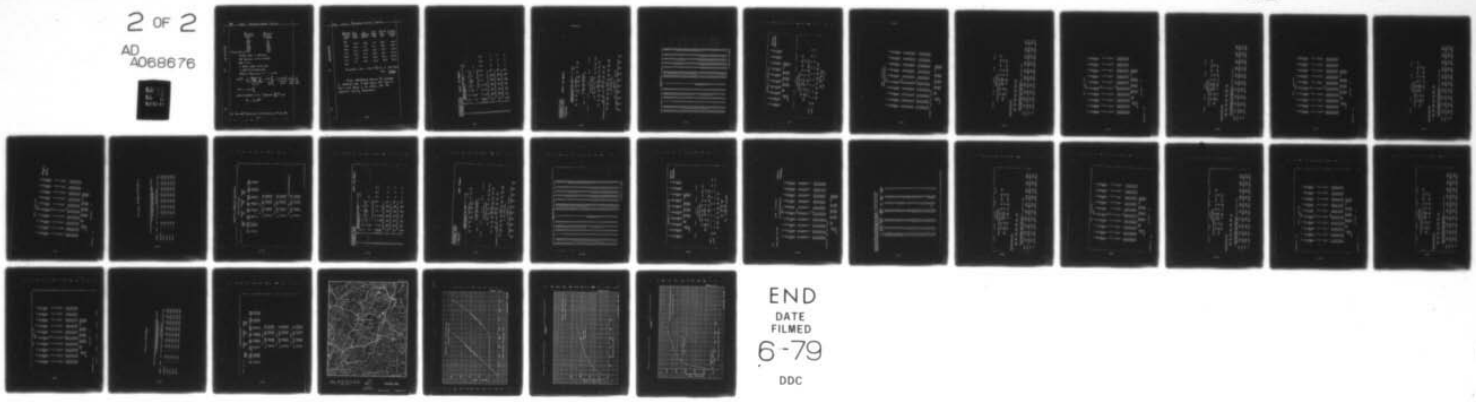
Location map of cross-sections used in routing calculations



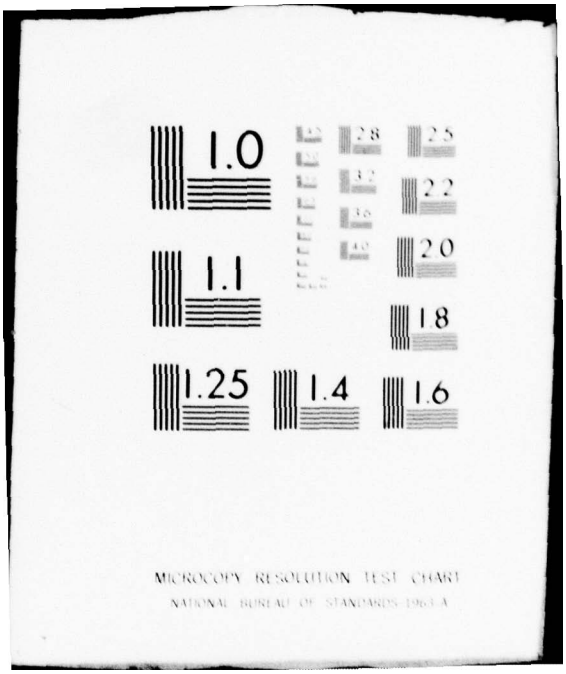
AD-A068 676 NEW JERSEY STATE DEPT OF ENVIRONMENTAL PROTECTION TRENTON F/G 13/2
NATIONAL DAM SAFETY PROGRAM. ORANGE RESERVOIR DAM (NJ 00361), R--ETC(U)
FEB 79 R J JENNY DACW61-78-C-0124

UNCLASSIFIED NL

2 OF 2
AD A068676



END
DATE FILMED
6-79
DDC


1.0
1.1
1.25
1.4
1.6
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.8
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

Reservoir Elevation feet	Reservoir Storage acre. feet
300	0
310	35
315	110
320	250
325	440
330	700
Spillway Elev. → 331	770

Outlet elev. = 295 feet

20" diameter (area = 2.18 sq. ft)

280' long

1 Valve, gate - wide open.

2 - 45° bends (assumed)

Assume Manning's "n" = 0.02

$$\text{Loss}^{1/} = \underbrace{.02 \frac{280 \times 12}{20} \frac{V^2}{2g}}_{\text{friction}} + \underbrace{0.8 \frac{V^2}{2g}}_{\text{entrance}} + \underbrace{2 \times .42 \times \frac{V^2}{2g}}_{\text{elbows}} + \underbrace{.19 \frac{V^2}{2g}}_{\text{valve}} + \underbrace{\frac{V^2}{2g}}_{\text{exit}}$$

$$\text{Loss} = 6.19 \frac{V^2}{2g}$$

$$\text{MEAN DISCHARGE} = V \times A = \left[(\text{Avg. Head}) \times \frac{2g}{6.19}\right]^{1/2} \times 2.18$$

$$\bar{Q} = 7.04 \sqrt{\bar{H}}$$

1/ Vennard, "Elementary Fluid Mechanics", 4th ed., 1961

Reservoir Elevation feet	Avg. head feet	Δ Storage $ft^3 \times 10^6$	Avg Disch cfs	Drawdown Time Hrs	Cum. Drawdown Time Hours
331					
	35.5	3.05	41.9	20.2	20.2
330					
	32.5	11.3	40.1	78.3	98.5
325					
	27.5	8.28	36.9	62.3	160.8
320					
	22.5	6.10	33.4	50.7	211.5
315					
	17.5	3.27	29.4	30.9	242.4
310					
	10	1.52	27.3	18.9	261.3
300					

Drawdown time = 261.3 hours = 10.9 days

Say 11 days

These calculations assume the tailwater is constant and 5 feet below the reservoir floor and there is no inflow into the reservoir during drawdown.

INPUT - NO BREACH

```
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION  JULY 1978
 LAST MODIFICATION  25 SEP 78
     1  A1    NEW JERSEY DAM SAFETY - ORANGE RESERVOIR DAM  I.D. NO. 00361
     2  A2    HYDRAULIC-HYDROLOGIC ANALYSIS  302-83
     3  A3    PROBABLE MAXIMUM FLOOD                                    -RBE-
     4  9    125       0      30       0       0       0       0       0       0       0
     5  B1     5
     6  J      1       7       1
     7  J1   0.1    0.15    0.20    0.25     0.5    0.75     1.0
     8  K      0       1                                                 1
     9  K1                                    4.62
    10  Y      1       0    4.62     113     123     132     142     1.0    0.10
    11  P             22.6
    12  T
    13  V   1.76    3.27
    14  X     -1    -.05     2.0                                         1
    15  K      1       2
    16  K1                                    ROUTED FLOWS THROUGH RESERVOIR
    17  Y                                       1       1                     770
    18  Y1     1
    19  SS     0      35     110     250     440     700     770     910    1060    1240
    20  SS  1575
    21  SE   300     310     315     320     325     330     331     333     335     337
    22  SE   340
    23  SS   331    71.5     3.2     1.5     900                             1
    24  SQ 334.4     3.1     1.5
    25  K      1       3
    26  K1                    CHANNEL ROUTING -MODIFIED PULS- STATION 2 TO 3
    27  Y                                       1       1
    28  Y1     1                                                          0.01
    29  Y6  0.10   0.045    0.10     240     300     610*    245     225     240     275     240
    30  Y7     0     100     150     260     225     245     300
    31  Y7   275     242     500     260     650     300                     1
    32  K      1       4
    33  K1                    CHANNEL ROUTING -MODIFIED PULS- STATION 3 TO 4
    34  Y                                       1       1
    35  Y1     1                                                          0.012
    36  Y6  0.10   0.045    0.10     162     230     635*    167     225     162     275     162
    37  Y7     0     203     150     190     225     167     208
    38  Y7   275     167     350     180     560     208                     1
    39  K      1       5
    40  K1                    CHANNEL ROUTING -MODIFIED PULS- STATION 4 TO 5
    41  Y                                       1       1
    42  Y1     1                                                          0.012
    43  Y6  0.05    0.45    0.05     140     180    1960     142     668     140     748     140
    44  Y7     0     100     150     160     600     142     100
    45  Y7   700   141.5    1450     160    1650     100
    46  K     99
```

INPUT - NO BREACH

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
 LAST MODIFICATION  25 SEP 78
**********

RUN  DATE= 12/18/78
     TIME= 22.44.06.
```

NEW JERSEY DAM SAFETY - ORANGE RESERVOIR DAM I.D. NO. 00361
HYDRAULIC-HYDROLOGIC ANALYSIS 102-03
PROBABLE MAXIMUM FLOOD -ABE-

JOB SPECIFICATION

NQ	NMR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
125	0	30	0	3	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 7 LRTIO= 1

RTIOS=	.10	.15	.20	.25	.50	.75	1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH TO RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	0	4.52	6.00	4.62	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	22.60	113.00	123.00	132.00	142.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .000

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.10	0.00	0.00

UNIT HYDROGRAPH DATA
TC= 1.76 R= 3.27 NTA= 0

RECESSION DATA
STRTQ= -1.00 QRCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 37 END-OF-PERIOD ORDINATES, LAG= 1.76 HOURS, CP= .41 VOL= 1.00

91.	331.	563.	678.	659.	522.	448.	384.	330.	283.
243.	209.	179.	153.	132.	113.	97.	83.	71.	61.
52.	45.	39.	33.	28.	24.	21.	18.	15.	13.
11.	10.	8.	7.	6.	5.	5.			

END-OF-PERIOD FLOW													
MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.30	1	.03	0.00	.00	4.	1.02	7.30	63	.15	.10	.05	124.
1.01	1.00	2	.00	0.00	.03	4.	1.02	8.00	64	.15	.10	.05	189.
1.01	1.30	3	.03	0.00	.00	4.	1.02	8.30	65	.15	.10	.05	247.
1.01	2.00	4	.03	0.00	.00	4.	1.02	9.00	66	.15	.10	.05	297.
1.01	2.30	5	.03	0.00	.03	3.	1.02	9.30	67	.15	.10	.05	340.
1.01	3.00	6	.00	0.00	.00	3.	1.02	10.00	68	.15	.10	.05	377.
1.01	3.30	7	.00	0.00	.00	3.	1.02	10.30	69	.15	.10	.05	408.
1.01	4.00	8	.00	0.00	.00	3.	1.02	11.00	70	.15	.10	.05	432.
1.01	4.30	9	.00	0.00	.00	2.	1.02	11.30	71	.15	.10	.05	450.
1.01	5.00	10	.00	0.00	.00	2.	1.02	12.00	72	.15	.10	.05	470.
1.01	5.30	11	.00	0.00	.00	2.	1.02	12.30	73	1.02	.97	.05	574.
1.01	6.00	12	.00	0.00	.00	2.	1.02	13.00	74	1.02	.97	.05	677.
1.01	6.30	13	.01	0.00	.01	2.	1.02	13.30	75	1.23	1.18	.05	1010.
1.01	7.00	14	.01	0.00	.01	2.	1.02	14.00	76	1.23	1.18	.05	2378.
1.01	7.30	15	.01	0.00	.01	2.	1.02	14.30	77	1.53	1.48	.05	2765.
1.01	8.00	16	.01	0.00	.01	2.	1.02	15.00	78	1.53	1.48	.05	3006.
1.01	8.30	17	.01	0.00	.01	1.	1.02	15.30	79	1.86	1.81	.05	4196.
1.01	9.00	18	.01	0.00	.01	1.	1.02	16.00	80	5.98	5.65	.05	5324.
1.01	9.30	19	.01	0.00	.01	1.	1.02	16.30	81	1.43	1.38	.05	7019.
1.01	10.00	20	.01	0.00	.01	1.	1.02	17.00	82	1.43	1.38	.05	8063.
1.01	10.30	21	.01	0.00	.01	1.	1.02	17.30	83	1.12	1.07	.05	9295.
1.01	11.00	22	.01	0.00	.01	1.	1.02	18.00	84	1.12	1.07	.05	9190.
1.01	11.30	23	.01	0.00	.01	1.	1.02	18.30	85	.08	.03	.05	8761.
1.01	12.00	24	.01	0.00	.01	1.	1.02	19.00	86	.08	.03	.05	8078.
1.01	12.30	25	.08	0.00	.08	1.	1.02	19.30	87	.08	.03	.05	7169.
1.01	13.00	26	.08	0.00	.08	1.	1.02	20.00	88	.08	.03	.05	6214.
1.01	13.30	27	.09	0.00	.09	1.	1.02	20.30	89	.08	.03	.05	5357.
1.01	14.00	28	.09	0.00	.09	1.	1.02	21.00	90	.08	.03	.05	4622.
1.01	14.30	29	.12	0.00	.12	1.	1.02	21.30	91	.08	.03	.05	3992.
1.01	15.00	30	.12	0.00	.12	1.	1.02	22.00	92	.08	.03	.05	3452.
1.01	15.30	31	.14	0.00	.14	1.	1.02	22.30	93	.08	.03	.05	2986.
1.01	16.00	32	.45	.31	.14	28.	1.02	23.00	94	.08	.03	.05	2598.
1.01	16.30	33	.11	.06	.05	108.	1.02	23.30	95	.08	.03	.05	2249.
1.01	17.00	34	.11	.06	.05	235.	1.03	0.00	96	.08	.03	.05	1956.
1.01	17.30	35	.09	.04	.05	263.	1.03	.30	97	0.00	0.00	0.00	1702.
1.01	18.00	36	.09	.04	.05	276.	1.03	1.00	98	0.00	0.00	0.00	1479.
1.01	18.30	37	.01	0.00	.01	266.	1.03	1.30	99	0.00	0.00	0.00	1272.
1.01	19.00	38	.01	0.00	.01	248.	1.03	2.00	100	0.00	0.00	0.00	1092.
1.01	19.30	39	.01	0.00	.01	220.	1.03	2.30	101	0.00	0.00	0.00	936.
1.01	20.00	40	.01	0.00	.01	190.	1.03	3.00	102	0.00	0.00	0.00	803.
1.01	20.30	41	.01	0.00	.01	163.	1.03	3.30	103	0.00	0.00	0.00	689.
1.01	21.00	42	.01	0.00	.01	140.	1.03	4.00	104	0.00	0.00	0.00	590.
1.01	21.30	43	.01	0.00	.01	120.	1.03	4.30	105	0.00	0.00	0.00	506.
1.01	22.00	44	.01	0.00	.01	103.	1.03	5.00	106	0.00	0.00	0.00	451.
1.01	22.30	45	.01	0.00	.01	89.	1.03	5.30	107	0.00	0.00	0.00	421.
1.01	23.00	46	.01	0.00	.01	76.	1.03	6.00	108	0.00	0.00	0.00	393.
1.01	23.30	47	.00	0.00	.01	65.	1.03	6.30	109	0.00	0.00	0.00	367.
1.02	0.00	48	.01	0.00	.01	56.	1.03	7.00	110	0.00	0.00	0.00	342.
1.02	.30	49	.05	.00	.05	48.	1.03	7.30	111	0.00	0.00	0.00	319.
1.02	1.00	50	.05	.00	.05	43.	1.03	8.00	112	0.00	0.00	0.00	298.
1.02	1.30	51	.05	.00	.05	41.	1.03	8.30	113	0.00	0.00	0.00	278.
1.02	2.00	52	.05	.00	.05	37.	1.03	9.00	114	0.00	0.00	0.00	259.
1.02	2.30	53	.05	.00	.05	36.	1.03	9.30	115	0.00	0.00	0.00	242.
1.02	3.00	54	.05	.00	.05	34.	1.03	10.00	116	0.00	0.00	0.00	226.
1.02	3.30	55	.05	.00	.05	33.	1.03	10.30	117	0.00	0.00	0.00	211.
1.02	4.00	56	.05	.00	.05	32.	1.03	11.00	118	0.00	0.00	0.00	196.
1.02	4.30	57	.05	.00	.05	31.	1.03	11.30	119	0.00	0.00	0.00	183.
1.02	5.00	58	.05	.00	.05	30.	1.03	12.00	120	0.00	0.00	0.00	171.
1.02	5.30	59	.05	.00	.05	29.	1.03	12.30	121	0.00	0.00	0.00	160.
1.02	6.00	60	.05	.00	.05	29.	1.03	13.00	122	0.00	0.00	0.00	149.
1.02	6.30	61	.15	.10	.05	37.	1.03	13.30	123	0.00	0.00	0.00	139.
1.02	7.00	62	.15	.10	.05	69.	1.03	14.00	124	0.00	0.00	0.00	130.
							1.03	14.30	125	0.00	0.00	0.00	121.
									SUM	25.07	21.96	3.71	132369.
										(652.1(	556.1(	94.1(	3761.56)

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 7

4.	4.	4.	4.	3.	3.	3.	3.	2.	2.
2.	2.	2.	2.	2.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	28.	188.	285.	263.	270.	268.	248.	228.	198.
163.	146.	128.	113.	89.	76.	65.	50.	48.	43.
48.	37.	36.	34.	33.	32.	31.	30.	29.	29.
37.	69.	124.	189.	247.	297.	348.	377.	438.	435.
456.	478.	574.	677.	1+16.	2874.	2765.	3466.	4196.	5324.
7819.	6683.	9295.	9193.	8761.	8878.	7569.	6213.	5357.	4622.
3992.	3452.	2986.	2593.	2249.	1956.	1742.	1479.	1472.	1892.
536.	631.	669.	596.	536.	451.	421.	393.	367.	342.
319.	258.	278.	259.	242.	220.	211.	190.	183.	171.
168.	149.	139.	130.	121.					

INFLOW Hydrograph

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	9295.	6977.	2645.	1863.	132846.
CMS	263.	198.	75.	38.	3762.
INCHES		14.65	21.38	22.29	22.29
MM		356.83	541.61	566.17	566.17
AC-FT		3468.	5246.	5498.	5493.
THOUS CU M		4267.	6478.	6771.	6771.

HYDROGRAPH ROUTING

ROUTED FLOWS THROUGH RESERVOIR

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	770.	0

CAPACITY=	0.	39.	116.	258.	448.	758.	770.	916.	1860.	12+0.
	1575.									
ELEVATION=	308.	318.	315.	328.	325.	338.	335.	333.	335.	337.
	348.									

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
331.0	71.5	3.2	1.5	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
334.0	3.1	1.5	938.

STATION 2, PLAN 1, RATIO 1

STATION 2. PLAN 1. RATIO 7

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	4.	14.	34.	68.	88.	112.	131.	142.
148.	148.	146.	148.	133.	125.	117.	109.	103.	93.
86.	73.	74.	69.	64.	64.	57.	54.	51.	48.
47.	47.	53.	66.	86.	112.	144.	179.	217.	255.
292.	327.	369.	447.	612.	893.	1313.	2079.	3024.	4767.
6289.	8019.	9188.	9266.	8425.	8332.	7312.	6081.	5736.	4935.
4279.	3716.	3232.	2787.	2426.	2124.	1866.	1646.	1466.	1378.
1267.	1155.	1062.	935.	835.	746.	671.	607.	552.	535.
465.	432.	349.	371.	346.	323.	341.	282.	264.	248.
232.	218.	205.	192.	181.					

STORAGE

770.	770.	771.	771.	771.	771.	771.	771.	771.	771.
771.	771.	771.	771.	772.	772.	772.	772.	772.	772.
772.	772.	772.	772.	772.	772.	772.	772.	772.	772.
772.	772.	775.	781.	790.	799.	817.	814.	810.	821.
822.	822.	822.	828.	819.	817.	815.	813.	810.	808.
806.	805.	803.	801.	800.	799.	798.	797.	796.	795.
794.	795.	796.	800.	806.	813.	821.	838.	838.	845.
852.	853.	866.	879.	915.	966.	1000.	1049.	1075.	1094.
1126.	1147.	1163.	1165.	1161.	1152.	1140.	1125.	1110.	1097.
1064.	1073.	1062.	1053.	1046.	1038.	1032.	1025.	1017.	1007.
995.	981.	966.	952.	938.	925.	914.	904.	896.	889.
882.	877.	871.	867.	862.	858.	854.	850.	847.	844.
841.	838.	835.	832.	830.					

STAGE

331.0	331.0	331.0	331.0	331.0	331.0	331.0	331.0	331.0	331.0
331.0	331.0	331.0	331.0	331.0	331.0	331.0	331.0	331.0	331.0
331.0	331.0	331.0	331.0	331.0	331.0	331.0	331.0	331.0	331.0
331.0	331.0	331.1	331.2	331.3	331.4	331.5	331.6	331.6	331.6
331.7	331.7	331.7	331.7	331.7	331.7	331.6	331.6	331.7	331.7
331.5	331.5	331.5	331.4	331.4	331.4	331.4	331.0	331.6	331.5
331.3	331.4	331.4	331.4	331.5	331.6	331.7	331.9	331.9	331.4
332.2	332.3	332.4	332.0	332.9	333.5	334.2	334.9	335.2	335.4
335.7	336.0	336.1	336.2	336.1	336.0	335.8	335.7	335.6	335.4
335.3	335.1	335.0	334.9	334.8	334.7	334.6	334.5	334.4	334.3
334.1	333.9	333.7	333.6	333.4	333.2	333.0	332.9	332.8	332.7
332.6	332.5	332.4	332.4	332.3	332.3	332.2	332.1	332.1	332.1
332.0	332.0	331.9	331.9	331.9					

PEAK OUTFLOW IS 9266. AT TIME 42.00 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	9266.	6359.	2638.	1051.	131485.
CMS	262.	197.	74.	30.	3721.
INCHES		14.81	21.18	22.85	22.85
MM		355.88	537.97	568.83	568.83
AC-FT		3451.	5216.	5436.	5433.
THOUS CU M		4256.	6434.	6698.	6698.

HYDROGRAPH ROUTING

CHANNEL ROUTING -MODIFIED PULS- STATION 2 TO 3

ISTAJ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
3	1	0	0	0	0	1	0	6

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELMVT	ELMAX	RLNTH	SEL
.1000	.0450	.1000	240.0	300.0	6100.	.01000

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 310.00 150.00 262.00 225.00 245.00 225.00 240.00 275.00 240.00
275.00 242.00 500.00 260.00 650.00 300.00

STORAGE	0.00	23.20	51.13	122.23	287.76	317.74	452.15	667.69	774.05	932.30
	1148.31	1330.72	1547.61	1766.98	1996.82	2237.13	2487.92	2749.14	3020.92	3303.12
OUTFLOW	0.00	1262.67	3567.66	7010.63	14115.04	22793.57	34133.33	49133.73	67375.16	88000.60
	112347.78	139110.90	168769.54	201367.16	236952.56	275570.31	317299.68	362173.69	410259.57	461010.35
STAGE	240.00	243.16	246.32	249.47	252.63	255.79	258.95	262.11	265.26	268.42
	271.58	274.74	277.89	281.05	284.21	287.37	290.53	293.68	296.84	300.00
FLOW	0.00	1262.67	3567.66	7010.63	14115.04	22793.57	34133.33	49133.73	67375.16	88000.60
	112347.78	139110.90	168769.54	201367.16	236952.56	275570.31	317299.68	362173.69	410259.57	461010.35

STATION 3, PLAN 1, RTIO 7

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	3.	9.	24.	47.	73.	99.	121.	136.
145.	140.	147.	143.	137.	129.	121.	113.	105.	97.
89.	83.	77.	71.	67.	62.	59.	55.	52.	50.
44.	47.	53.	59.	75.	98.	127.	161.	197.	235.
272.	359.	347.	466.	526.	746.	1039.	2075.	3371.	4460.
5729.	7488.	8793.	9269.	9060.	8539.	7795.	6913.	6002.	5195.
4562.	3987.	3468.	2949.	2551.	2232.	1958.	1724.	1529.	1461.
1336.	1196.	1063.	988.	888.	793.	711.	641.	581.	532.
486.	449.	415.	386.	359.	335.	313.	292.	274.	256.
248.	226.	212.	199.	187.					

STOR

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	1.	1.	2.	2.	3.	3.
3.	3.	3.	3.	3.	3.	3.	2.	2.	2.
2.	2.	2.	2.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	2.	2.	3.	4.	4.	5.
6.	7.	9.	9.	12.	14.	24.	39.	58.	74.
92.	116.	136.	142.	139.	132.	122.	109.	96.	85.
75.	66.	59.	52.	46.	41.	37.	33.	30.	28.
27.	25.	24.	22.	19.	17.	16.	14.	13.	12.
11.	10.	9.	8.	8.	7.	7.	6.	6.	6.
5.	5.	5.	4.	4.					

STAGE

240.0	240.0	240.0	240.0	240.0	240.0	240.0	240.0	240.0	240.0
240.0	240.0	240.0	240.0	240.0	240.0	240.0	240.0	240.0	240.0
240.0	240.0	240.0	240.0	240.0	240.0	240.0	240.0	240.0	240.0
240.0	240.0	240.0	240.0	240.1	240.1	240.2	240.3	240.4	240.4
240.4	240.4	240.4	240.4	240.4	240.4	240.4	240.3	240.3	240.3
240.3	240.2	240.2	240.2	240.2	240.2	240.2	240.2	240.2	240.1
240.1	240.1	240.1	240.2	240.2	240.3	240.4	240.5	240.6	240.7
240.8	240.9	241.2	241.2	241.6	242.2	243.2	244.4	246.1	247.8
247.5	249.2	251.1	253.2	250.1	249.8	249.5	248.8	248.1	247.5
247.0	246.6	246.1	245.5	245.0	244.6	244.3	244.0	243.7	243.6
243.5	243.3	243.2	242.9	242.6	242.4	242.1	241.9	241.7	241.6
241.4	241.3	241.2	241.1	241.1	241.0	240.9	240.9	240.8	240.8
240.7	240.7	240.6	240.6	240.6					

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	9269.	6949.	2630.	1859.	131386.
CMS	262.	197.	74.	53.	3716.
INCHES		13.99	21.18	22.03	22.03
MM		355.41	537.97	559.61	559.61
AC-FT		3446.	5216.	5426.	5426.
THOUS CU M		4251.	6434.	6693.	6693.

MAXIMUM STORAGE = 142.

MAXIMUM STAGE IS 253.2

HYDROGRAPH ROUTING

CHANNEL ROUTING -MODIFIED PULS- STATION 3 TO 4

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
4	1	0	0	0	6	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	LPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELMVT	ELMAX	RLNTH	SEL
.1000	.0450	.1000	162.3	200.0	6350.	.01200

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 200.00 150.00 183.30 225.00 167.30 225.00 162.00 275.00 162.00
275.00 167.00 350.00 180.30 500.00 200.00

STORAGE	0.00	14.52	29.16	44.57	65.00	93.91	128.60	170.17	218.34	273.11
	336.01	407.44	487.62	576.54	674.21	780.63	895.79	1019.70	1152.36	1293.76
OUTFLOW	0.00	546.90	1655.75	3167.62	5249.10	7883.00	11154.63	15119.10	19831.35	25343.21
	31572.15	38776.17	47322.44	56376.73	66983.12	78643.97	91728.51	106138.54	121953.00	139245.43
STAGE	162.00	164.63	166.03	168.00	170.00	172.00	174.00	176.00	178.00	180.00
	182.00	184.00	186.00	188.00	190.00	192.00	194.00	196.00	198.00	200.00
FLOW	0.00	546.90	1655.75	3167.62	5249.10	7883.00	11154.63	15119.10	19831.35	25343.21
	31572.15	38776.17	47322.44	56376.73	66983.12	78643.97	91728.51	106138.54	121953.00	139245.43

STATION 4, PLAN 1, RTIO 7

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	2.	5.	15.	33.	56.	83.	107.	126.
139.	145.	147.	145.	141.	134.	127.	118.	110.	102.
94.	87.	81.	75.	70.	65.	61.	58.	54.	52.
49.	48.	48.	54.	65.	84.	109.	139.	174.	213.
249.	285.	322.	370.	454.	639.	985.	1727.	3867.	4204.
5394.	6949.	8471.	9211.	9149.	8687.	8238.	7747.	6237.	5334.
4668.	4051.	3521.	3057.	2645.	2385.	2822.	1779.	1582.	1439.
1334.	1233.	1119.	1017.	928.	823.	736.	662.	599.	546.
513.	473.	437.	405.	376.	351.	327.	306.	286.	268.
251.	235.	221.	207.	195.					

STOR

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	1.	2.	2.	3.	3.
4.	4.	4.	4.	4.	4.	3.	3.	3.	3.
3.	2.	2.	2.	2.	2.	2.	2.	1.	1.
1.	1.	1.	1.	2.	2.	3.	4.	5.	6.
7.	8.	9.	10.	12.	16.	20.	33.	43.	55.
67.	84.	100.	100.	107.	102.	95.	86.	76.	67.
60.	53.	48.	43.	39.	36.	33.	30.	28.	26.
25.	24.	22.	21.	19.	18.	17.	16.	15.	15.
14.	13.	12.	11.	10.	9.	9.	8.	8.	7.
7.	6.	6.	6.	5.					

STAGE

162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8
162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8
162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8
162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8
162.5	162.5	162.5	162.5	162.5	162.5	162.5	162.5	162.5	162.5
162.3	162.3	162.3	162.3	162.3	162.3	162.3	162.3	162.3	162.3
162.2	162.2	162.2	162.2	162.2	162.3	162.3	162.3	162.3	162.3
162.9	163.0	163.2	163.4	163.7	164.2	164.8	166.1	167.8	169.8
170.1	171.3	172.4	172.8	172.8	172.5	172.1	171.4	170.7	170.1
169.4	168.8	168.3	167.8	167.3	166.8	166.5	166.2	165.9	165.6
165.4	165.2	165.0	164.8	164.7	164.5	164.3	164.2	164.1	164.0
163.9	163.7	163.6	163.5	163.4	163.3	163.2	163.1	163.0	163.0
162.9	162.9	162.8	162.8	162.7					

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	9211.	6953.	2629.	1849.	131186.
CMS	261.	197.	74.	38.	3715.
INCHES		14.88	21.16	22.81	22.81
MM		355.57	537.91	559.88	559.88
AC-FT		1446.	5215.	5421.	5421.
THOUS CU M		4252.	6433.	6686.	6686.

MAXIMUM STORAGE = 188.

MAXIMUM STAGE IS 172.8

D-19

HYDROGRAPH ROUTING

CHANNEL ROUTING -MODIFIED PULS- STATION 4 TO 5

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
5	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELMVT	ELMAX	RLNTH	SEL
.0500	.4500	.0500	140.0	180.0	1900.	.01200

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 190.30 150.00 160.30 600.00 142.00 600.60 140.00 700.00 140.00
700.00 141.50 1450.00 160.00 1650.30 180.00

STORAGE	0.00	9.51	27.53	58.21	101.56	157.59	226.28	307.64	401.68	508.38
	626.69	749.36	875.50	1005.02	1137.93	1274.22	1413.90	1556.90	1703.48	1853.22
OUTFLOW	0.00	133.58	1197.48	4789.86	12145.27	24307.89	42215.49	66733.45	98673.15	136833.47
	192180.58	258659.90	333555.21	416658.24	507976.78	607319.08	714683.66	830052.24	953424.71	1084815.44
STAGE	140.00	142.11	144.21	146.32	148.42	150.53	152.63	154.74	156.84	158.95
	161.05	163.16	165.26	167.37	169.47	171.58	173.68	175.79	177.89	180.00
FLOW	0.00	133.58	1197.48	4789.86	12145.27	24307.89	42215.49	66733.45	98673.15	136833.47
	192180.58	258659.90	333555.21	416658.24	507976.78	607319.08	714683.66	830052.24	953424.71	1084815.44

STATION 5, PLAN 1, RTIO 7

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	2.	6.	14.	28.	46.	60.	98.
109.	124.	134.	147.	143.	137.	132.	128.	122.	115.
107.	109.	93.	86.	80.	74.	69.	65.	61.	57.
54.	52.	50.	51.	55.	64.	78.	99.	125.	186.
233.	273.	307.	350.	418.	559.	837.	1466.	2762.	3969.
5169.	6726.	8254.	9167.	9187.	8769.	8137.	7277.	6367.	5509.
4760.	4190.	3610.	3153.	2726.	2371.	2078.	1827.	1619.	1465.
1354.	1254.	1155.	1059.	960.	863.	771.	692.	625.	567.
526.	493.	452.	418.	348.	361.	337.	314.	294.	275.
259.	242.	227.	213.	200.					

STOR

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	2.	0.	0.	0.	1.	2.	3.	5.	6.
8.	9.	10.	10.	10.	10.	9.	9.	9.	8.
8.	7.	7.	6.	6.	5.	5.	5.	4.	4.
4.	4.	4.	4.	4.	5.	6.	7.	9.	10.
11.	12.	12.	13.	14.	17.	21.	33.	41.	51.
60.	73.	79.	84.	84.	82.	78.	73.	68.	62.
58.	53.	48.	44.	41.	38.	35.	33.	31.	30.
29.	28.	27.	25.	23.	22.	20.	19.	18.	17.
15.	16.	15.	14.	14.	13.	13.	13.	12.	12.
12.	11.	11.	11.	11.					

STAGE

140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0
140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.3	140.0
140.0	140.0	140.0	140.3	140.0	140.6	140.0	140.0	140.0	140.0
140.0	140.0	140.3	140.0	140.1	140.2	140.4	140.7	141.1	141.4
141.7	141.9	142.1	142.1	142.1	142.1	142.1	142.0	141.9	141.0
141.7	141.6	141.5	141.4	141.3	141.2	141.1	141.0	141.0	140.9
140.9	140.8	140.8	140.8	140.9	141.0	141.2	141.6	142.0	142.2
142.3	142.4	142.4	142.5	142.7	142.9	143.5	144.4	145.1	145.0
146.4	146.9	147.3	147.6	147.6	147.5	147.3	147.0	146.0	146.5
146.3	146.0	145.6	145.4	145.1	144.9	144.7	144.6	144.5	144.4
144.3	144.2	144.1	143.9	143.7	143.5	143.4	143.2	143.1	143.0
142.9	142.8	142.7	142.7	142.6	142.6	142.5	142.5	142.4	142.4
142.4	142.3	142.3	142.3	142.2					

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	9187.	6949.	2629.	1047.	130923.
CMS	260.	197.	74.	30.	3707.
INCHES		13.99	21.16	21.97	21.97
MM		355.39	537.98	557.98	557.98
AC-FT		3446.	5215.	5410.	5410.
THOUS CU M		4250.	6433.	6673.	6673.

MAXIMUM STORAGE = 84.

MAXIMUM STAGE IS 147.6

Community of Millburn

Summary - No Breach Calculations

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS						
				RATIO 1 .13	RATIO 2 .15	RATIO 3 .28	RATIO 4 .25	RATIO 5 .58	RATIO 6 .75	RATIO 7 1.00
HYDROGRAPH AT	1	4.62	1	938.	1394.	1659.	2324.	4648.	6971.	9295.
	(	11.97)	(	26.32)(	39.48)(	52.64)(	65.80)(	131.61)(	197.41)(	263.21)(
ROUTED TO	2	4.62	1	726.	1125.	1625.	2232.	4620.	6940.	9266.
	(	11.97)	(	20.55)(	31.86)(	46.02)(	63.21)(	130.99)(	196.75)(	262.39)(
ROUTED TO	3	4.62	1	719.	1126.	1591.	2236.	4602.	6913.	9269.
	(	11.97)	(	20.36)(	31.89)(	45.05)(	63.33)(	130.31)(	196.36)(	262.47)(
ROUTED TO	4	4.62	1	721.	1119.	1597.	2236.	4581.	6880.	9211.
	(	11.97)	(	20.41)(	31.68)(	45.22)(	62.47)(	129.72)(	194.83)(	260.82)(
ROUTED TO	5	4.62	1	717.	1119.	1589.	2236.	4597.	6911.	9187.
	(	11.97)	(	20.32)(	31.68)(	44.99)(	63.33)(	130.17)(	195.71)(	260.15)(

D-22

Summary - No Breach Calculations

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	331.66	331.88	334.40
STORAGE	770.	770.	1815.
OUTFLOW	0.	0.	1434.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.13	333.16	0.00	922.	726.	0.00	43.50	0.00
.15	333.89	0.00	977.	1125.	0.00	43.50	0.00
.20	334.52	.12	1024.	1625.	1.50	43.00	0.00
.25	334.75	.35	1041.	2232.	3.50	42.50	0.00
.50	335.34	.94	1091.	4620.	7.50	42.00	0.00
.75	335.79	1.39	1131.	6948.	9.50	42.00	0.00
1.00	336.17	1.77	1165.	9266.	11.00	42.00	0.00

PLAN 1 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	719.	242.1	43.50
.15	1126.	243.2	43.50
.20	1591.	243.8	43.50
.25	2236.	244.6	42.50
.50	4632.	247.1	42.00
.75	6934.	248.8	42.00
1.00	9269.	250.2	42.00

PLAN 1 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	721.	164.3	44.00
.15	1119.	165.0	43.50
.20	1597.	165.9	43.50
.25	2226.	166.7	43.00
.50	4561.	169.4	42.50
.75	6888.	171.2	42.00
1.00	9211.	172.8	42.00

PLAN 1 STATION 5 Community of Millburn

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	717.	143.3	44.00
.15	1119.	144.1	44.00
.20	1589.	144.4	43.50
.25	2236.	144.8	43.00
.50	4537.	146.2	42.50
.75	6911.	146.9	42.50
1.00	9197.	147.6	42.50

INPUT - DAM BREACH

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
 LAST MODIFICATION  25 SEP 78
**********
    1            A1      NEW JERSEY DAM SAFETY - ORANGE RESERVOIR DAM  I.D. NO. 00361
    2            A2      HYDRAULIC-HYDROLOGIC ANALYSIS   302-83
    3            A3      PROBABLE MAXIMUM FLOOD                                    -RBE-
    4            9    125       0      30       0       0       0       0        0       0       0
    5            B1     5
    6            J      1       7       1
    7            J1   0.1    0.15    0.20    0.25     0.5    0.75     1.0
    8            K      0       1                                                  1
    9            K1                          INFLOW HYDROGRAPH TO RESERVOIR
   10            M      1       0    4.62               4.62                                1
   11            P             22.6     113     123     132     142
   12            T                                                      1.0    0.18
   13            V   1.76    3.27
   14            X     -1    -.05     2.0
   15            K      1       2                                                  1
   16            K1                          ROUTED FLOWS THROUGH RESERVOIR
   17            Y                                   1       1
   18            Y1     1                                                      770
   19            ES     0      35     110     250     440     700     770      910    1060    1240
   20            ES  1575
   21            SE   360     310     315     320     325     330     331      333     335     337
   22            SE   340
   23            SS   331    31.5     3.2     1.5
   24            SD 334.4     3.1     1.5     930
   25            ID — 30       1     300     2.5     331   334.4
   26            K      1       3                                                  1
   27            K1      CHANNEL ROUTING -MODIFIED PULS- STATION 2 TO 3
   28            Y                                   1       1
   29            Y1     1
   30            Y6  0.10   0.045    0.10     240     330    6100    0.81
   31            Y7     0     300     150     260     225     245     225      240     275     246
   32            Y7   275     242     500     260     650     300
   33            K      1       4                                                  1
   34            K1      CHANNEL ROUTING -MODIFIED PULS- STATION 3 TO 4
   35            Y                                   1       1
   36            Y1     1
   37            Y6  0.10   0.045    0.10     162     200    6350    0.812
   38            Y7     0     200     150     140     225     167     225      162     275     162
   39            Y7   275     167     350     180     500     200
   40            K      1       5                                                  1
   41            K1      CHANNEL ROUTING -MODIFIED PULS- STATION 4 TO 5
   42            Y                                   1       1
   43            Y1     1
   44            Y6  0.05    0.45    0.05     140     180    1900    0.312
   45            Y7     0     100     150     160     600     142     600      140     700     140
   46            Y7   700   141.5    1450     160    1650     160
   47            K     99
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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  25 SEP 78
**********

RUN  DATE= 12/18/78
     TIME= 22.46.35.
```

INPUT - BREACH

NEW JERSEY DAM SAFETY - ORANGE RESERVOIR DAM I.D. NO. 00361
HYDRAULIC-HYDROLOGIC ANALYSIS 302-03
PROBABLE MAXIMUM FLOOD -RBE-

JOB SPECIFICATION

NI	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
125	0	30	0	0	0	0	0	0	0

	JOPER	NWT	LROPT	TRACE
	5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 7 LRTIO= 1

RTIOS= .10 .15 .20 .25 .50 .75 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH TO RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	4

HYDROGRAPH DATA

IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISHOW	ISAME	LOCAL
1	0	4.62	0.00	4.62	0.60	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	22.60	113.00	123.00	132.00	142.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .000

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.10	3.00	0.00

UNIT HYDROGRAPH DATA
TC= 1.76 R= 3.27 NTA= 0

RECESSION DATA
STRTQ= -1.00 QRCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 37 END-OF-PERIOD ORDINATES, LAG= 1.76 HOURS, CP= .41 VOL= 1.00

91.	331.	583.	676.	609.	522.	448.	384.	333.	283.
243.	208.	179.	153.	132.	113.	97.	83.	71.	61.
52.	45.	39.	33.	28.	24.	21.	18.	15.	13.
11.	10.	8.	7.	6.	5.	5.			

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						END-OF-PERIOD FLOW							
MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.30	1	.00	0.00	.00	4.	1.02	7.30	61	.15	.10	.05	124.
1.01	1.00	2	.01	0.00	.01	4.	1.02	8.00	64	.15	.10	.05	109.
1.01	1.30	3	.00	0.00	.00	4.	1.02	8.30	65	.15	.10	.05	247.
1.01	2.00	4	.00	0.00	.00	4.	1.02	9.00	66	.15	.10	.05	297.
1.01	2.30	5	.00	0.00	.00	3.	1.02	9.30	67	.15	.10	.05	340.
1.01	3.00	6	.00	0.00	.00	3.	1.02	10.00	68	.15	.10	.05	377.
1.01	3.30	7	.00	0.00	.00	3.	1.02	10.30	69	.15	.10	.05	408.
1.01	4.00	8	.00	0.00	.00	3.	1.02	11.00	70	.15	.10	.05	435.
1.01	4.30	9	.00	0.00	.00	2.	1.02	11.30	71	.15	.10	.05	458.
1.01	5.00	10	.00	0.00	.00	2.	1.02	12.00	72	.15	.10	.05	478.
1.01	5.30	11	.00	0.00	.00	2.	1.02	12.30	73	1.02	.97	.05	574.
1.01	6.00	12	.00	0.00	.00	2.	1.02	13.00	74	1.02	.97	.05	677.
1.01	6.30	13	.01	0.00	.01	2.	1.02	13.30	75	1.23	1.18	.05	1416.
1.01	7.00	14	.01	0.00	.01	2.	1.02	14.00	76	1.23	1.18	.05	2278.
1.01	7.30	15	.01	0.00	.01	2.	1.02	14.30	77	1.53	1.48	.05	2765.
1.01	8.00	16	.01	0.00	.01	2.	1.02	15.00	78	1.53	1.48	.05	3466.
1.01	8.30	17	.01	0.00	.01	1.	1.02	15.30	79	1.86	1.81	.05	4196.
1.01	9.00	18	.01	0.00	.01	1.	1.02	16.00	80	5.98	5.85	.05	5324.
1.01	9.30	19	.01	0.00	.01	1.	1.02	16.30	81	1.43	1.38	.05	7819.
1.01	10.00	20	.01	0.00	.01	1.	1.02	17.00	82	1.43	1.38	.05	8033.
1.01	10.30	21	.01	0.00	.01	1.	1.02	17.30	83	1.12	1.07	.05	9233.
1.01	11.00	22	.01	0.00	.01	1.	1.02	18.00	84	1.12	1.07	.05	9198.
1.01	11.30	23	.01	0.00	.01	1.	1.02	18.30	85	.88	.83	.05	8761.
1.01	12.00	24	.01	0.00	.01	1.	1.02	19.00	86	.88	.83	.05	8478.
1.01	12.30	25	.06	0.00	.06	1.	1.02	19.30	87	.88	.83	.05	7169.
1.01	13.00	26	.06	0.00	.06	1.	1.02	20.00	88	.88	.83	.05	6213.
1.01	13.30	27	.09	0.00	.09	1.	1.02	20.30	89	.88	.83	.05	5357.
1.01	14.00	28	.09	0.00	.09	1.	1.02	21.00	90	.88	.83	.05	4622.
1.01	14.30	29	.12	0.00	.12	1.	1.02	21.30	91	.88	.83	.05	3992.
1.01	15.00	30	.12	0.00	.12	1.	1.02	22.00	92	.68	.63	.05	3452.
1.01	15.30	31	.14	0.00	.14	1.	1.02	22.30	93	.68	.63	.05	2988.
1.01	16.00	32	.45	.31	.14	28.	1.02	23.00	94	.68	.63	.05	2598.
1.01	16.30	33	.11	.06	.05	188.	1.02	23.30	95	.68	.63	.05	2249.
1.01	17.00	34	.11	.06	.05	285.	1.03	0.00	96	.68	.63	.05	1956.
1.01	17.30	35	.09	.04	.05	263.	1.03	.30	97	0.68	0.00	0.68	1702.
1.01	18.00	36	.09	.04	.05	270.	1.03	1.00	98	0.68	0.00	0.68	1475.
1.01	18.30	37	.01	0.00	.01	268.	1.03	1.30	99	0.68	0.00	0.68	1272.
1.01	19.00	38	.01	0.00	.01	248.	1.03	2.00	100	0.68	0.00	0.68	1092.
1.01	19.30	39	.01	0.00	.01	228.	1.03	2.30	101	0.00	0.00	0.00	936.
1.01	20.00	40	.01	0.00	.01	190.	1.03	3.00	102	0.00	0.00	0.00	803.
1.01	20.30	41	.01	0.00	.01	163.	1.03	3.30	103	0.00	0.00	0.00	689.
1.01	21.00	42	.01	0.00	.01	140.	1.03	4.00	104	0.00	0.00	0.00	590.
1.01	21.30	43	.01	0.00	.01	121.	1.03	4.30	105	0.00	0.00	0.00	506.
1.01	22.00	44	.01	0.00	.01	103.	1.03	5.00	106	0.00	0.00	0.00	451.
1.01	22.30	45	.01	0.00	.01	89.	1.03	5.30	107	0.00	0.00	0.00	421.
1.01	23.00	46	.01	0.00	.01	76.	1.03	6.00	108	0.00	0.00	0.00	393.
1.01	23.30	47	.01	0.00	.01	65.	1.03	6.30	109	0.00	0.00	0.00	367.
1.02	0.00	48	.01	0.00	.01	56.	1.03	7.00	110	0.00	0.00	0.00	342.
1.02	.30	49	.05	.00	.05	48.	1.03	7.30	111	0.00	0.00	0.00	319.
1.02	1.00	50	.05	.00	.05	43.	1.03	8.00	112	0.00	0.00	0.00	296.
1.02	1.30	51	.05	.00	.05	40.	1.03	8.30	113	0.00	0.00	0.00	278.
1.02	2.00	52	.05	.00	.05	37.	1.03	9.00	114	0.00	0.00	0.00	259.
1.02	2.30	53	.05	.00	.05	36.	1.03	9.30	115	0.00	0.00	0.00	242.
1.02	3.00	54	.05	.00	.05	34.	1.03	10.00	116	0.00	0.00	0.00	226.
1.02	3.30	55	.05	.00	.05	33.	1.03	10.30	117	0.00	0.00	0.00	211.
1.02	4.00	56	.05	.00	.05	32.	1.03	11.00	118	0.00	0.00	0.00	196.
1.02	4.30	57	.05	.00	.05	31.	1.03	11.30	119	0.00	0.00	0.00	183.
1.02	5.00	58	.05	.00	.05	30.	1.03	12.00	120	0.00	0.00	0.00	171.
1.02	5.30	59	.05	.00	.05	29.	1.03	12.30	121	0.00	0.00	0.00	160.
1.02	6.00	60	.05	.00	.05	29.	1.03	13.00	122	0.00	0.00	0.00	149.
1.02	6.30	61	.15	.10	.05	37.	1.03	13.30	123	0.00	0.00	0.00	139.
1.02	7.00	62	.15	.10	.05	69.	1.03	14.00	124	0.00	0.00	0.00	130.
							1.03	14.30	125	0.00	0.00	0.00	121.
									SUM	25.07	21.96	3.71	132969.
										(652.11	568.11	96.11	3761.50

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 7

4.	4.	4.	4.	3.	3.	3.	3.	2.	2.
2.	2.	2.	2.	2.	2.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	29.	138.	285.	263.	276.	268.	246.	228.	198.
163.	143.	123.	103.	89.	76.	65.	56.	48.	43.
40.	37.	36.	34.	33.	32.	31.	30.	29.	29.
37.	69.	124.	189.	247.	297.	340.	377.	406.	435.
456.	478.	574.	877.	1416.	2078.	2769.	3466.	4196.	5324.
7819.	8683.	9295.	9190.	8761.	8078.	7169.	6213.	5257.	4622.
3992.	3452.	2988.	2598.	2249.	1956.	1702.	1479.	1272.	1092.
936.	803.	683.	590.	506.	451.	421.	393.	367.	342.
319.	298.	278.	259.	242.	226.	211.	196.	183.	171.
160.	149.	139.	130.	121.					

INFLOW Hydrograph

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	9295.	6977.	2645.	1863.	132840.
CMS	263.	198.	75.	38.	3762.
INCHES		14.85	21.38	22.29	22.29
MM		356.83	543.01	566.17	566.17
AC-FT		3466.	5246.	5498.	5498.
THOUS CU M		4267.	6470.	6771.	6771.

L2-D

HYDROGRAPH ROUTING

ROUTED FLOWS THROUGH RESERVOIR

ISTAQ	ICOPP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	3	8	8	8	1	8	8

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
8.8	8.888	8.86	1	1	8	8	8

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	8	8	8.888	8.888	8.888	778.	8

CAPACITY=	8.	35.	115.	250.	448.	700.	778.	913.	1868.	1248.
	1575.									
ELEVATION=	308.	318.	315.	320.	325.	330.	331.	333.	335.	337.
	340.									

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
331.8	71.5	3.2	1.5	8.8	8.8	8.8	8.8

DAM DATA

TOPEL	COOD	EXPD	DAMWID
334.4	3.1	1.5	988.

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	MSEL	FAILEL
38.	1.88	330.88	2.5h	331.88	334.48

DUN

STATION 2. PLAN 1. RATIO 7

BEGIN DAM FAILURE AT 39.00 HOURS

OUTFLOW Hydrograph

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	4.	14.	34.	60.	88.	112.	131.	142.
149.	148.	146.	140.	133.	125.	117.	109.	100.	93.
85.	79.	74.	69.	64.	60.	57.	54.	51.	48.
47.	47.	53.	66.	86.	112.	144.	179.	217.	255.
292.	327.	369.	447.	612.	893.	1313.	2589.	4863.	7549.
11353.	14954.	16317.	18759.	9218.	8591.	7736.	6733.	5734.	4976.
4318.	3751.	2961.	2697.	2277.	2017.	1741.	1521.	1312.	1131.
972.	836.	718.	617.	531.	467.	438.	463.	376.	351.
328.	346.	286.	267.	249.	232.	217.	203.	189.	177.
165.	154.	144.	134.	126.					

STORAGE

771.	771.	771.	771.	771.	771.	771.	771.	771.	771.
771.	771.	771.	771.	772.	772.	772.	772.	772.	772.
772.	772.	772.	772.	772.	772.	772.	772.	772.	772.
772.	772.	775.	781.	790.	799.	807.	814.	818.	821.
822.	822.	822.	820.	819.	817.	815.	813.	810.	808.
806.	805.	803.	801.	800.	799.	798.	797.	796.	795.
794.	795.	796.	808.	836.	873.	921.	838.	838.	845.
852.	853.	866.	879.	935.	946.	1030.	1049.	1051.	999.
862.	837.	334.	283.	161.	142.	119.	90.	78.	63.
49.	36.	31.	29.	26.	24.	22.	21.	19.	17.
16.	14.	13.	12.	11.	10.	9.	9.	9.	8.
8.	7.	7.	7.	7.	6.	6.	6.	5.	5.
5.	5.	5.	4.	4.					

STAGE

331.6	331.8	331.8	331.8	331.8	331.8	331.6	331.8	331.6	331.8
331.8	331.8	331.8	331.3	331.8	331.8	331.8	331.8	331.8	331.8
331.9	331.8	331.8	331.8	331.8	331.6	331.8	331.8	331.8	331.8
331.6	331.8	331.1	331.2	331.3	331.4	331.5	331.6	331.7	331.7
331.7	331.7	331.7	331.7	331.7	331.7	331.6	331.6	331.6	331.5
331.5	331.5	331.5	331.4	331.4	331.4	331.4	331.4	331.4	331.4
331.3	331.4	331.4	331.4	331.5	331.6	331.7	331.9	332.0	332.1
332.2	332.3	332.4	332.6	332.9	333.5	334.2	334.8	334.9	334.2
332.3	328.8	322.7	318.3	316.8	316.1	315.3	314.1	312.9	311.9
311.8	311.1	308.8	308.3	307.5	307.8	306.4	305.9	305.4	304.9
304.5	304.1	303.7	303.4	303.8	302.8	302.7	302.6	302.4	302.3
302.2	302.1	302.8	302.8	331.9	331.6	331.7	331.6	331.6	331.5
331.4	331.4	331.3	331.3	331.2					

PEAK OUTFLOW IS 16284. AT TIME 41.35 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	16317.	9917.	3866.	1213.	1515e9.
CMS	454.	255.	87.	34.	4292.
INCHES		18.15	24.65	25.43	25.43
MM		461.14	625.99	645.97	645.97
AC-FT		4471.	6069.	6263.	6263.
THOUS CU M		5515.	7487.	7726.	7726.

D-28

THE DAM BREACH HYDROGRAPH WAS DEVELOPED USING A TIME INTERVAL OF .050 HOURS DURING BREACH FORMATION.
DOWNSTREAM CALCULATIONS WILL USE A TIME INTERVAL OF .500 HOURS.
THIS TABLE COMPARES THE HYDROGRAPH FOR DOWNSTREAM CALCULATIONS WITH THE COMPUTED BREACH HYDROGRAPH.
INTERMEDIATE FLOWS ARE INTERPOLATED FROM END-OF-PERIOD VALUES.

TIME (HOURS)	TIME FROM BEGINNING OF BREACH (HOURS)	INTERPOLATED BREACH HYDROGRAPH (CFS)	-	COMPUTED BREACH HYDROGRAPH (CFS)	=	ERROR (CFS)	ACCUMULATED ERROR (CFS)	ACCUMULATED ERROR (AC-FT)
39.000	0.000	2569.		2569.		0.	0.	0.
39.050	.050	2816.		2837.		-21.	-21.	-0.
39.100	.100	3044.		3109.		-65.	-86.	-0.
39.150	.150	3271.		3338.		-67.	-153.	-1.
39.200	.200	3498.		3581.		-82.	-235.	-1.
39.250	.250	3726.		3814.		-88.	-324.	-1.
39.300	.300	3953.		4018.		-65.	-388.	-2.
39.350	.350	4180.		4253.		-73.	-461.	-2.
39.400	.400	4408.		4461.		-53.	-514.	-2.
39.450	.450	4635.		4664.		-29.	-543.	-2.
39.500	.500	4863.		4863.		0.	-543.	-2.
39.550	.550	5131.		5059.		72.	-471.	-2.
39.600	.600	5458.		5264.		186.	-285.	-1.
39.650	.650	5669.		5470.		198.	-142.	-1.
39.700	.700	5937.		5690.		246.	97.	0.
39.750	.750	6206.		5930.		275.	373.	2.
39.800	.800	6475.		6179.		296.	669.	3.
39.850	.850	6743.		6451.		292.	961.	4.
39.900	.900	7012.		6773.		239.	1199.	5.
39.950	.950	7281.		7163.		118.	1317.	5.
40.000	1.000	7549.		7549.		0.	1317.	5.
40.050	1.050	7938.		7935.		-5.	1312.	5.
40.100	1.100	8318.		8321.		-11.	1301.	5.
40.150	1.150	8695.		8764.		-18.	1282.	5.
40.200	1.200	9071.		9095.		-24.	1256.	5.
40.250	1.250	9451.		9482.		-31.	1227.	5.
40.300	1.300	9831.		9868.		-36.	1191.	5.
40.350	1.350	10212.		10254.		-42.	1149.	5.
40.400	1.400	10592.		10621.		-29.	1120.	5.
40.450	1.450	10973.		10986.		-14.	1106.	5.
40.500	1.500	11353.		11361.		-8.	1106.	5.
40.550	1.550	11713.		11722.		-9.	1097.	5.
40.600	1.600	12073.		12095.		-22.	1076.	4.
40.650	1.650	12433.		12474.		-41.	1035.	4.
40.700	1.700	12793.		12865.		-72.	963.	4.
40.750	1.750	13154.		13288.		-134.	829.	3.
40.800	1.800	13514.		13718.		-204.	625.	3.
40.850	1.850	13874.		14137.		-263.	362.	1.
40.900	1.900	14234.		14475.		-241.	121.	0.
40.950	1.950	14594.		14718.		-124.	-3.	-0.
41.000	2.000	14954.		14954.		0.	-3.	-0.
41.050	2.050	15061.		15181.		-120.	-123.	-1.
41.100	2.100	15167.		15393.		-227.	-350.	-1.
41.150	2.150	15273.		15594.		-321.	-670.	-3.
41.200	2.200	15379.		15782.		-403.	-1073.	-4.
41.250	2.250	15486.		15963.		-474.	-1547.	-6.
41.300	2.300	15592.		16128.		-536.	-2083.	-9.
41.350	2.350	15698.		16284.		-586.	-2669.	-11.
41.400	2.400	15805.		16172.		-367.	-3036.	-13.
41.450	2.450	15911.		16084.		-173.	-3209.	-13.
41.500	2.500	16017.		16017.		0.	-3209.	-13.

HYDROGRAPH ROUTING

CHANNEL ROUTING -MODIFIED PULS- STATION 2 TO 3

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
3	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELMVT	ELMAX	RLNTH	SEL
.1000	.0450	.1000	240.0	300.0	6100.	.01000

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 311.00 150.00 260.00 225.00 245.00 225.00 240.00 275.00 240.00
275.00 242.00 500.00 260.00 650.00 300.00

STORAGE	0.00	23.20	61.13	122.23	207.76	317.74	452.19	607.03	774.01	952.30
	1140.31	1330.72	1547.61	1766.98	1996.82	2237.13	2487.92	2749.16	4628.91	8333.12
OUTFLOW	0.00	1362.67	3567.66	7010.63	14115.84	22793.57	34133.33	49133.73	67379.16	88000.68
	112347.78	139118.93	168769.54	201367.16	236952.56	275578.31	317299.68	362173.89	410259.57	461616.35
STAGE	240.00	243.16	246.32	249.47	252.63	255.79	258.95	262.11	265.26	268.42
	271.58	274.74	277.89	281.05	284.21	287.37	290.53	293.68	296.84	300.00
FLOW	0.00	1362.67	3567.66	7010.63	14115.84	22793.57	34133.33	49133.73	67379.16	88000.00
	112347.79	139118.98	168769.54	201367.16	236952.56	275578.31	317299.68	362173.89	410259.57	461616.35

STATION 3, PLAN 1, RTIO 7

OUTFLOW

0.	0.	0.	0.	6.	0.	0.	0.	0.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	3.	9.	24.	47.	73.	99.	121.	136.
145.	140.	147.	143.	137.	129.	121.	113.	105.	97.
89.	83.	77.	71.	67.	62.	59.	55.	52.	58.
48.	47.	50.	59.	75.	98.	127.	161.	197.	235.
272.	369.	347.	486.	526.	746.	1099.	2884.	3969.	4682.
10512.	13865.	15883.	12526.	9488.	8778.	8848.	7181.	6361.	5229.
4543.	3944.	3258.	2763.	2444.	2161.	1845.	1596.	1369.	1196.
1934.	987.	781.	671.	577.	501.	458.	417.	390.	364.
340.	317.	296.	277.	256.	241.	225.	210.	196.	183.
171.	163.	149.	139.	130.					

STOR

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	1.	1.	2.	2.	3.	3.
3.	3.	3.	3.	3.	3.	3.	2.	2.	2.
2.	2.	2.	2.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	2.	2.	3.	4.	4.	5.
6.	7.	8.	9.	12.	16.	24.	39.	67.	105.
152.	204.	230.	198.	144.	135.	125.	112.	97.	85.
75.	67.	56.	49.	44.	39.	35.	31.	28.	25.
23.	23.	17.	15.	13.	11.	10.	9.	9.	8.
7.	7.	6.	6.	6.	5.	5.	5.	4.	4.
4.	4.	3.	3.	3.					

STAGE

240.0	240.0	240.3	240.0	240.6	240.0	240.6	240.0	240.0	240.0
240.0	240.0	240.3	240.0	240.6	240.6	240.0	240.0	240.6	240.6
240.0	240.0	240.3	240.0	240.0	240.6	240.6	240.6	240.0	240.6
240.6	240.0	240.3	240.0	240.1	240.1	241.2	240.3	240.4	240.4
240.4	240.4	240.4	240.4	240.4	240.4	240.4	240.3	240.3	240.3
240.3	240.2	240.2	240.2	240.2	240.2	240.2	240.2	240.2	240.1
240.1	240.1	240.1	240.2	240.2	240.3	240.4	240.5	240.0	240.7
240.8	240.9	241.0	241.2	241.6	242.2	243.2	244.4	240.6	240.6
250.6	252.5	253.3	252.0	250.3	250.0	249.6	248.9	248.2	247.6
247.6	246.6	245.3	245.3	244.9	244.5	244.1	243.8	243.0	243.3
243.1	242.7	242.3	242.0	241.7	241.5	241.3	241.2	241.2	241.1
241.8	240.9	240.9	240.8	240.8	240.7	240.7	240.6	240.6	240.5
240.5	240.5	240.4	240.4	240.4					

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	15888.	9181.	3068.	1212.	151563.
CMS	450.	255.	87.	34.	4293.
INCHES		18.12	24.64	25.42	25.42
MM		460.31	625.93	645.64	645.64
AC-FT		4463.	6069.	6260.	6260.
THOUS CU M		5565.	7486.	7722.	7722.

MAXIMUM STORAGE = 230.

MAXIMUM STAGE IS 253.3

HYDROGRAPH ROUTING

CHANNEL ROUTING -MODIFIED PULS- STATION 3 TO 4

ISTAQ	ICONP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
4	1	0	0	0	0	1	0	0

ROUTING DATA

GLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
6.0	0.000	0.00	1	1	0	0	3

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELMVT	ELMAX	RLNTH	SEL
.1000	.0450	.1000	162.0	280.0	6350.	.01200

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 288.00 150.00 180.00 225.00 167.00 225.60 162.00 275.00 162.00
275.00 167.00 350.00 180.00 500.00 288.00

STORAGE	0.00	14.58	29.16	44.57	65.00	93.91	128.60	170.17	218.30	273.33
	336.81	407.44	487.62	576.54	674.21	780.63	895.79	1019.74	1152.36	1293.70
OUTFLOW	0.00	546.90	1655.75	3187.62	5249.10	7803.00	11154.63	15119.10	19831.35	25303.21
	31572.15	38776.17	47322.44	56376.73	66963.12	78663.97	91728.01	106130.54	121953.00	139295.43
STAGE	162.00	164.00	166.00	168.00	170.00	172.00	174.00	176.00	178.00	180.00
	182.00	184.00	186.00	188.00	190.00	192.00	194.00	196.00	198.00	200.00
FLOW	0.00	546.90	1655.75	3187.62	5249.10	7803.00	11154.63	15119.10	19831.35	25303.21
	31572.15	38776.17	47322.44	56376.73	66963.12	78663.97	91728.01	106130.54	121953.00	139295.43

MAXIMUM STAGE IS 179.5

STATION 4, PLAN 1, RTIO 7

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	2.	5.	15.	33.	56.	83.	107.	126.
139.	145.	147.	145.	141.	134.	127.	118.	110.	102.
94.	87.	81.	75.	70.	65.	61.	58.	54.	52.
49.	48.	48.	54.	65.	84.	109.	139.	174.	216.
268.	285.	322.	378.	454.	639.	985.	1733.	3483.	>893.
9868.	12824.	15567.	13972.	10192.	8739.	8348.	7339.	6338.	5423.
4788.	4888.	3436.	2865.	2513.	2196.	1898.	1661.	1456.	1256.
1064.	946.	821.	705.	636.	531.	483.	448.	408.	381.
356.	332.	318.	283.	273.	252.	236.	228.	205.	192.
179.	167.	156.	146.	136.					

STOR

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	1.	2.	2.	3.	3.
4.	4.	4.	4.	4.	4.	3.	3.	3.	3.
3.	2.	2.	2.	2.	2.	2.	2.	1.	1.
1.	1.	1.	1.	2.	2.	3.	4.	5.	6.
7.	8.	9.	10.	12.	16.	20.	30.	48.	73.
107.	146.	174.	158.	118.	103.	90.	80.	77.	64.
60.	54.	47.	41.	36.	35.	32.	29.	27.	24.
22.	21.	18.	17.	15.	14.	13.	12.	11.	10.
9.	9.	8.	8.	7.	7.	6.	6.	5.	5.
5.	4.	4.	4.	4.					

STAGE

162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8
162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8
162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8
162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8	162.8
162.5	162.5	162.5	162.5	162.5	162.5	162.5	162.5	162.5	162.5
162.3	162.3	162.3	162.3	162.3	162.2	162.2	162.2	162.2	162.2
162.2	162.2	162.2	162.2	162.2	162.2	162.2	162.2	162.2	162.2
162.9	163.0	163.2	163.4	163.7	164.2	164.8	166.1	168.3	173.5
172.7	174.8	176.2	175.4	173.4	172.5	172.3	171.6	171.8	171.1
169.5	168.9	168.2	167.6	167.3	166.7	166.3	166.8	165.6	165.3
165.8	164.7	164.5	164.3	164.1	163.9	163.8	163.6	163.5	163.4
163.3	163.2	163.1	163.1	163.0	162.9	162.9	162.8	162.8	162.7
162.7	162.6	162.6	162.5	162.5					

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	15587.	9975.	3868.	1211.	151412.
CMS	439.	254.	87.	34.	4268.
INCHES		10.87	24.64	25.41	25.41
MM		459.81	625.91	645.38	645.38
AC-FT		4458.	6869.	6257.	6257.
THOUS CU M		5496.	7486.	7716.	7716.

MAXIMUM STORAGE = 174.

MAXIMUM STAGE IS 176.2

D-33

HYDROGRAPH ROUTING

CHANNEL ROUTING -MODIFIED PULS- STATION 4 TO 5

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
5	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPNP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELMVT	ELMAX	RLNTH	SEL
.0500	.4500	.0500	140.0	180.0	1900.	.01200

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 180.00 150.00 160.00 600.00 142.00 600.00 140.00 700.00 140.00
700.00 141.50 1450.00 160.00 1650.00 180.00

STORAGE	0.00	9.51	27.53	58.21	101.56	157.59	226.28	307.64	401.68	508.38
	626.60	749.36	875.50	1005.02	1137.93	1274.22	1413.90	1556.96	1703.40	1853.22
OUTFLOW	0.00	133.58	1197.48	4789.86	12145.27	24337.69	42215.49	66733.45	98673.15	138033.47
	192189.58	258659.93	333555.21	416698.24	507976.78	607319.08	714683.66	830452.24	953424.71	1084615.44
STAGE	140.00	142.11	144.21	146.32	148.42	150.53	152.63	154.74	156.84	158.95
	161.05	163.16	165.26	167.37	169.47	171.58	173.68	175.79	177.89	180.00
FLOW	0.00	133.58	1197.48	4789.86	12145.27	24337.69	42215.49	66733.45	98673.15	138033.47
	192189.59	258659.90	333555.21	416698.24	507976.78	607319.08	714683.66	830452.24	953424.71	1084615.44

STATION 9, PLAN 1, RTIO 7

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	2.	6.	14.	28.	46.	68.	90.
109.	124.	134.	147.	143.	137.	132.	128.	122.	115.
107.	103.	93.	86.	80.	74.	69.	65.	61.	57.
54.	52.	53.	51.	55.	64.	78.	99.	125.	186.
233.	278.	387.	353.	418.	559.	837.	1472.	3879.	5412.
8640.	12243.	15387.	14328.	10719.	8760.	8392.	7506.	6466.	5554.
4794.	4234.	3568.	2979.	2509.	2261.	1954.	1787.	1496.	1297.
1135.	1003.	872.	752.	646.	561.	501.	457.	421.	392.
366.	342.	319.	298.	278.	260.	242.	226.	211.	197.
184.	172.	161.	150.	140.					

STOR

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	1.	0.	0.	1.	2.	3.	5.	6.
8.	9.	10.	10.	10.	10.	9.	9.	9.	8.
8.	7.	7.	6.	6.	5.	5.	5.	4.	4.
4.	4.	4.	4.	4.	5.	6.	7.	9.	10.
11.	12.	12.	13.	14.	17.	21.	30.	44.	62.
81.	102.	116.	112.	93.	82.	79.	74.	68.	63.
58.	53.	48.	43.	39.	37.	34.	32.	30.	28.
26.	24.	22.	20.	18.	17.	16.	15.	14.	14.
13.	13.	13.	12.	12.	12.	11.	11.	11.	11.
10.	10.	10.	10.	10.					

STAGE

140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0
140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0
140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0
140.0	140.0	140.0	140.0	140.1	140.2	140.4	140.7	141.1	141.4
141.7	141.9	142.1	142.1	142.1	142.1	142.1	142.0	141.9	141.8
141.7	141.6	141.5	141.4	141.3	141.2	141.1	141.0	141.0	140.9
140.9	140.8	140.8	140.8	140.9	141.0	141.2	141.6	142.0	142.2
142.3	142.4	142.4	142.5	142.7	142.9	143.5	144.4	145.3	146.5
147.4	148.4	149.0	148.8	148.0	147.5	147.3	147.1	146.8	146.5
146.3	146.0	145.6	145.3	145.0	144.8	144.7	144.5	144.4	144.3
144.1	143.8	143.6	143.3	143.1	143.0	142.8	142.7	142.7	142.6
142.6	142.5	142.5	142.4	142.4	142.4	142.3	142.3	142.3	142.2
142.2	142.2	142.2	142.1	142.1					

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	15387.	8968.	3659.	1209.	151179.
CMS	436.	254.	87.	34.	4281.
INCHES		18.86	24.64	25.37	25.37
MM		458.64	625.88	644.31	644.31
AC-FT		4447.	6068.	6247.	6247.
THOUS CU M		5485.	7485.	7706.	7706.

MAXIMUM STORAGE = 116.

MAXIMUM STAGE IS 149.[illegible]

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Summary - Dam Breach

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS						
				RATIO 1 .10	RATIO 2 .15	RATIO 3 .20	RATIO 4 .25	RATIO 5 .50	RATIO 6 .75	RATIO 7 1.00
HYDROGRAPH AT	1	4.62	1	938.	1394.	1859.	2324.	4648.	6971.	9295.
	(	11.97)	(	26.32)(	39.48)(	52.64)(	65.80)(	131.61)(	197.41)(	263.21)(
ROUTED TO	2	4.62	1	726.	1125.	6424.	9395.	12262.	14866.	16817.
	(	11.97)	(	20.55)(	31.86)(	238.94)(	266.05)(	345.52)(	398.13)(	453.58)(
ROUTED TO	3	4.62	1	719.	1126.	8368.	9281.	11636.	14249.	16484.
	(	11.97)	(	20.36)(	31.89)(	237.29)(	262.88)(	329.53)(	402.23)(	466.68)(
ROUTED TO	4	4.62	1	721.	1119.	8137.	8374.	11818.	14124.	16587.
	(	11.97)	(	20.41)(	31.68)(	230.41)(	294.11)(	334.65)(	399.96)(	469.10)(
ROUTED TO	5	4.62	1	717.	1119.	7988.	8985.	11859.	14189.	16387.
	(	11.97)	(	20.32)(	31.68)(	225.97)(	252.16)(	335.82)(	399.51)(	435.71)(

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SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	331.00	331.00	334.40
STORAGE	770.	770.	1015.
OUTFLOW	0.	0.	1434.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	333.16	0.00	922.	726.	0.00	43.50	0.00
.15	333.69	0.00	977.	1125.	0.00	43.50	0.00
.20	334.47	.07	1620.	6699.	.83	44.35	42.53
.25	334.56	.16	1827.	9542.	.95	43.45	41.50
.50	334.69	.29	1837.	14374.	1.20	42.16	40.66
.75	334.90	.50	1852.	14665.	1.35	41.75	39.50
1.00	334.97	.57	1857.	16284.	1.35	41.35	39.00

PLAN 1 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	719.	242.1	43.50
.15	1126.	243.2	43.50
.20	8386.	249.8	44.50
.25	9201.	250.2	43.50
.50	11616.	251.4	42.50
.75	14239.	252.7	42.00
1.00	15880.	253.3	41.50

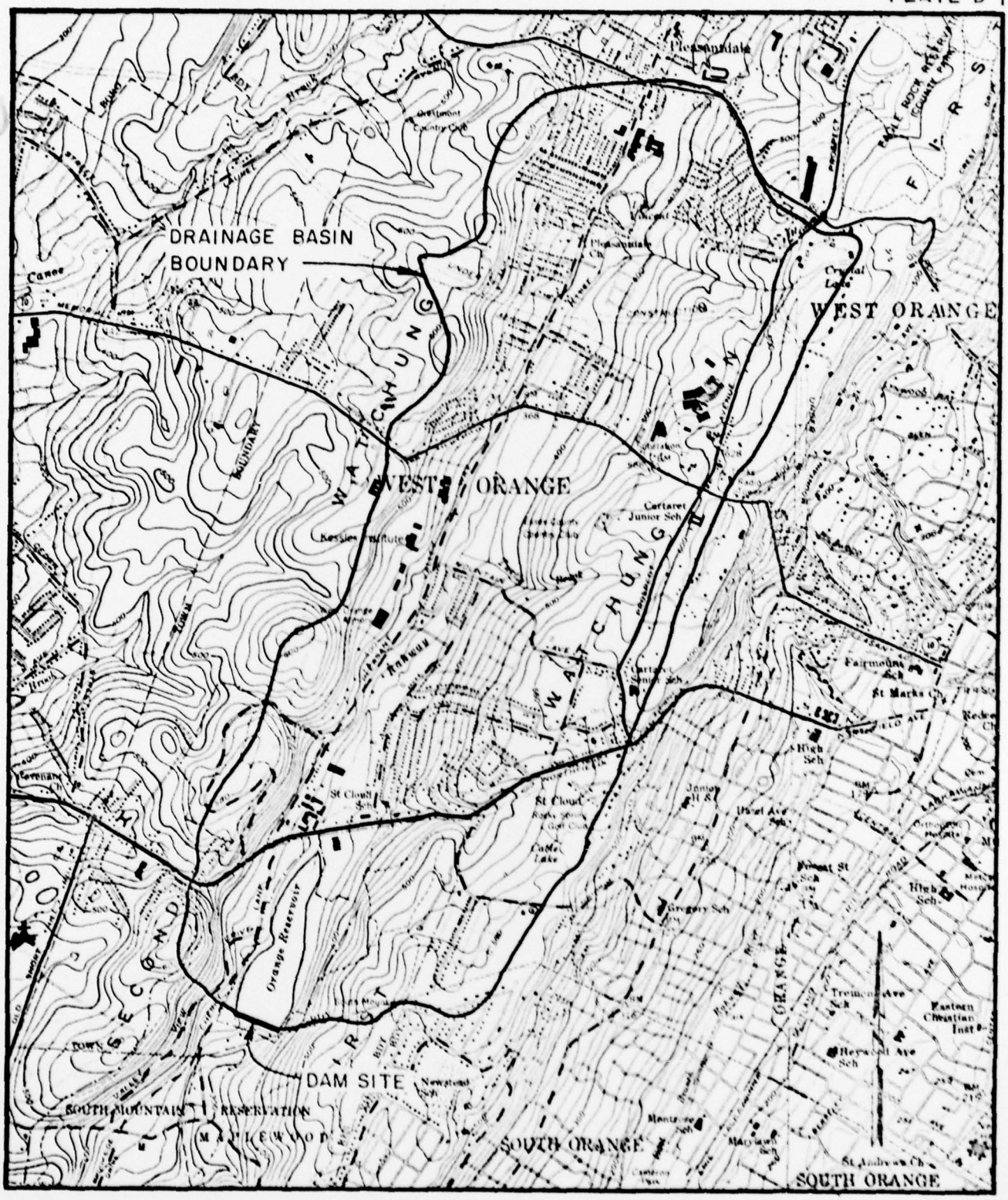
PLAN 1 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	721.	164.3	44.00
.15	1119.	165.6	43.50
.20	6137.	172.2	44.50
.25	8574.	172.7	43.50
.50	11818.	174.3	42.50
.75	14124.	175.5	42.00
1.00	15587.	176.2	41.50

PLAN 1 STATION 5

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	717.	143.3	44.00
.15	1119.	144.1	44.00
.20	7980.	147.2	44.50
.25	8935.	147.5	44.00
.50	11859.	148.3	42.50
.75	14139.	148.8	42.00
1.00	15357.	149.0	41.50

PLATE D-1



ORANGE DAM

JENNY/LEEDSHILL DECEMBER 1978

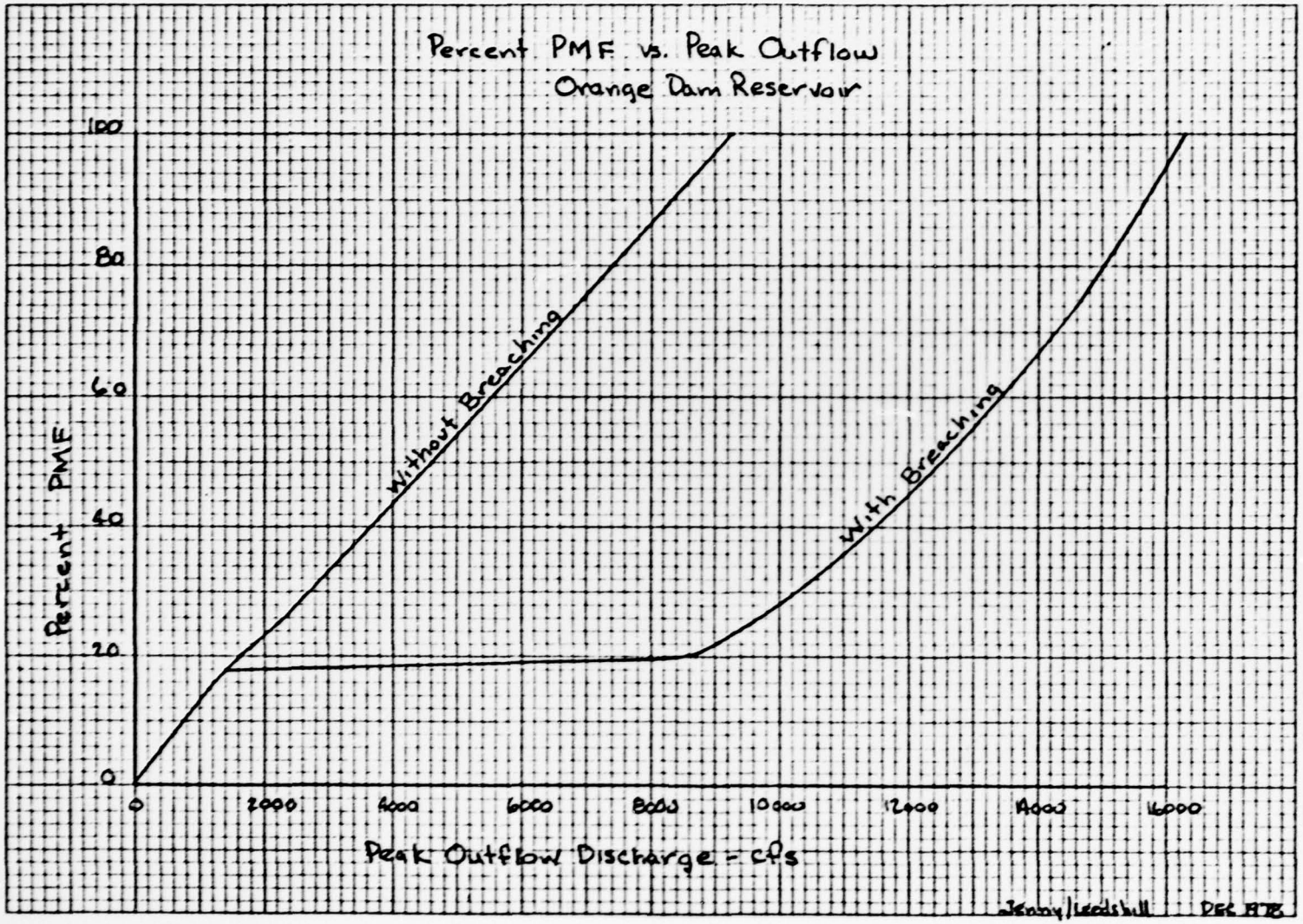

Percent PMF vs. Peak Outflow
Orange Dam Reservoir
Percent PMF
100
80
60
40
20
0
Without Breaching
With Breaching
0
2000
4000
6000
8000
10000
12000
14000
16000
Peak Outflow Discharge - cfs
Jenny/Leedshill
DEC 1978

PLATE D-2

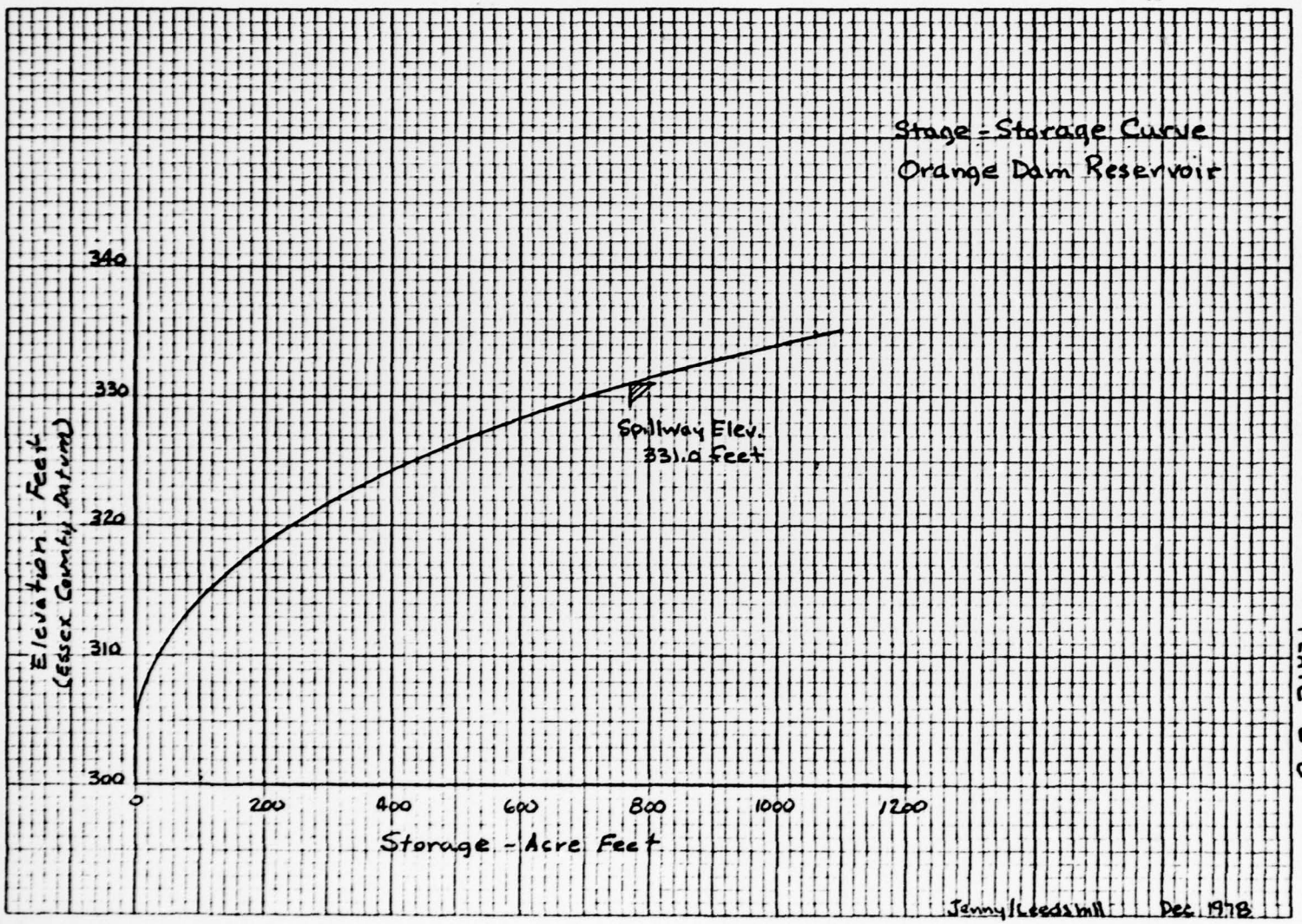


PLATE D-3

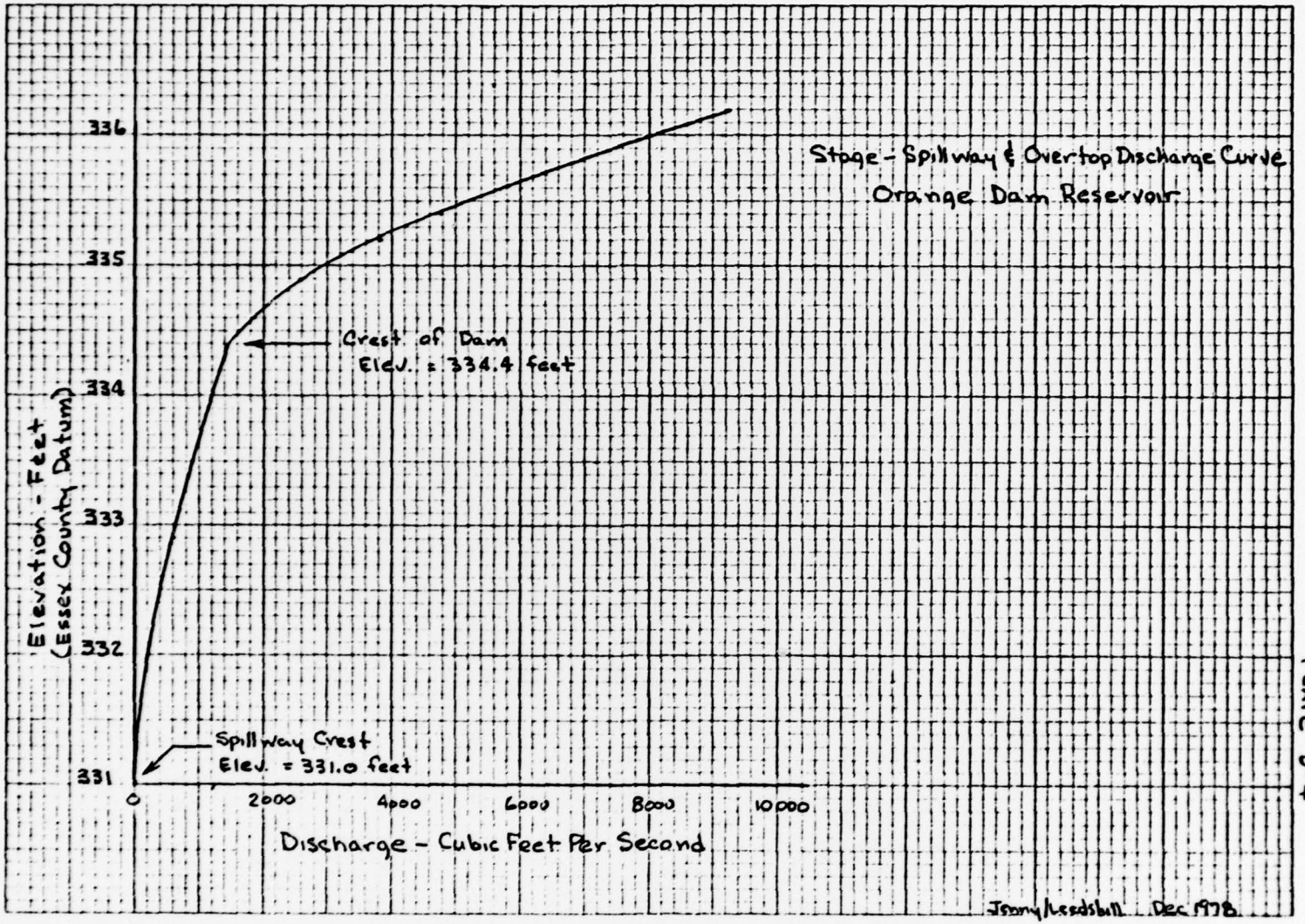


PLATE D-4